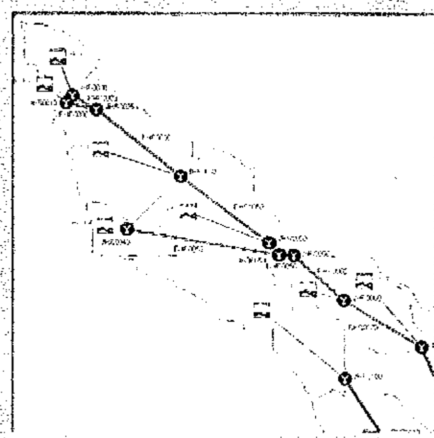


Haegler Ranch Basin

Drainage Basin Planning Study

May 2009

URS

TO: City of Colorado Springs
Planning Commission
P. O. Box 1575
Colorado Springs, Colorado 80901

Date: 5-29-09

This is to certify that the following items were received on the above-referenced date:

Amendment to the El Paso County Master Plan – Documents related to the Haegler Ranch Drainage Basin Planning Study.

Resolution No. MP-09-001 dated February 3, 2009 and May 5, 2009.

The enclosures pertain to the requirements set forth in Section 30-28-109, Colorado Revised Statutes, which state, in part:

"The County Planning Commission shall certify a copy of its master plan, or any adopted part or amendment thereof or addition thereto, to the Board of County Commissioners of the County."

"The County or regional planning commission shall certify such copies to the planning commission of all municipalities with the County or region."

For your information, Section 30-28-109 also states:

Any municipal planning commission which receives any such certification may adopt so much of the plan, part, amendment of or addition to the master plan of the municipality, and, when so adopted, it shall have the same force and effect as though made and prepared, as well as adopted, by such municipal planning commission.

R J Andrews
Signature of Recipient

HAEGLER RANCH
DRAINAGE BASIN PLANNING STUDY

MAY 2009

Prepared for:

El Paso County
Department of Transportation
3460 N. Marksheffel Road
Colorado Springs, CO 80922

Prepared By:

URS

URS Corporation
9960 Federal Drive, Suite 300
Colorado Springs, CO 80921

URS Project No. 21711039

DISCLAIMER:

This report has been prepared based on certain key assumptions made by URS, which substantially affect the conclusions and recommendations of this report. These assumptions, although thought to be reasonable and appropriate, may not prove true in the future. URS' conclusions and recommendations are conditioned upon these assumptions.

Background information, design bases, and other data have been furnished to URS by third parties, which URS has used in preparing this report. URS has relied on this information as furnished, and is not responsible for and has not confirmed the accuracy of this information.

The maps and photographs included in this report were developed for purposes of the El Paso County Department of Transportation (DOT) and are for internal use only. DOT makes no warranty, expressed or implied, as to the completeness, accuracy, or content of such products or any reproductions thereof. Any other use is not recommended and occurs at the risk of the user; such user is solely responsible and/or liable for the use of such products.

Regardless of the existence of purported copies of these official maps and photographs which may from time to time be made or published, there is only one set of official maps and photographs, which are those kept and maintained by DOT.

This page intentionally left blank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Engineer's Statement:

The attached HAEGLER RANCH DRAINAGE BASIN PLANNING STUDY was prepared under my direction and supervision and is correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports. I accept responsibility for any liability caused by any negligent acts, errors, and omissions on my part in preparing this report.

URS, 9960 Federal Drive, Suite 300, Colorado Springs, CO 80921

COLORADO REGISTERED JOHN S. GRIFFITH 16030 PROFESSIONAL ENGINEER

John S. Griffith
Registered Professional Engineer
State of Colorado
No. 16030

5/19/09
Date

This page intentionally left blank.

1.0 EXECUTIVE SUMMARY

1.1. Purpose and Scope

The purpose of the drainage Basin Planning Study (DBPS) is to identify a stormwater management plan for the existing and future stormwater and infrastructure needs within the Haegler Ranch Drainage Basin (Haegler Ranch). The scope of work for this DBPS includes:

- Obtain existing relevant data and general information from participating entities.
- Obtain current information for land use and future growth in Haegler Ranch.
- Gather information about right-of-way, known drainage problems, and proposed stormwater projects.
- Utilize the County policies, criteria, and applicable information wherever possible.
- Perform hydrologic and hydraulic analyses within Haegler Ranch at 2-, 5-, 10-, and 100-year intervals.
- Identify existing and potential stormwater and/or flooding problems.
- Develop improvement alternatives to reduce existing and potential flooding problems.
- Recommend and prepare a preliminary design for a selected alternative plan.
- Conduct an economic analysis of the preferred alternative.
- Develop drainage and bridge fees for Haegler Ranch.
- Prepare a written report discussing all items examined in the DBPS.

1.2. Location and Description

The Haegler Ranch Drainage Basin (Haegler Ranch) encompasses 16.6 square miles in unincorporated El Paso County, Colorado, and is a tributary to Black Squirrel Creek (see Figure 1-1). Haegler Ranch Basin is located in Sections 29, 32 and 33 of Township 12 South Range 64 West and sections 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, 22, 23, and 24 of Township 13 South, Range, 64 West and sections 18, 19, 20, 28, 29, 30, 31, 32, 33, and 34 of Township 13 South, Range 63 West and sections 2, 3, and 4 of Township 14 South, Range 63 West. Topography in the basin is rolling rangeland with poor vegetative cover associated with semi-arid climates. The Haegler Ranch consists of indistinct ephemeral streams that flow after storms for a short period of time, and the main stem of Haegler Ranch consists of dry natural grass swales with some poor quality riparian zones and small wetlands in the floodplains. The natural drainageways are generally shallow and wide, and flow paths are not well defined in many areas.

1.3. Land Use

As of July 2005, approximately 14 percent of the basin was developed. Much of this existing development consists of 2- to 5-acre lots and larger agricultural parcels south of US Hwy 24. Due to growth in the basin, land use is expected to change in the future with new low and medium density residential developments. Higher density residential developments such as Meridian Ranch, Santa Fe Springs, and Four Way Ranch are underway in the northwestern portions of the Haegler Ranch Basin. Meridian Ranch is in the north and Santa Fe Springs is in the central portion of the watershed. The area of Meridian Ranch within Haegler Ranch has high-density land uses of commercial and business, residential lots of 0.25 acres, and new paved roads with curb and gutter. Santa Fe Springs has a larger area in Haegler Ranch and a wider range of land uses including high density development such as commercial and business, residential lots of 0.125 acres, residential lots of 0.25 acres, schools, and new paved roads with curb and gutter as well as low density development such as residential large lots with 2% imperviousness, parks, and open space.

Future developed condition hydrology was modeled using proposed 2030 land uses from Colorado Springs Utilities Land Use Coverages (CSU 2005). The developed condition land uses are reasonably consistent with the Falcon Small Area Master Plan dated August 2008.

1.4. Hydrologic Analysis

As part of this study, hydrologic analyses for existing and future land use conditions were computed for the Haegler Ranch for 2-, 5-, 10-, and 100-year recurrence interval events using the USACE Hydrologic Engineering Center – Hydrologic Modeling System Version 2.2.2 (HEC-HMS). During the analyses, a portion of the original Haegler Ranch as delineated by the County map was found to be part of the Geick Ranch Drainage Basin at Judge Orr Road, due to the lack of a roadway culvert at the crossing. This area is excluded from the Haegler Ranch DBPS and is included as part of the Geick Ranch DBPS, per the County. Resulting flow rates and volumes are compared at key locations throughout the Haegler Ranch for both existing and future models. Generally, the largest flow and volume increases due to future development occur in the middle portion of the basin, assuming no detention. Since the future land use scenario does not include development in the lower portion of the watershed, potential increases in peak flows are attenuated and less at the mouth of the basin. The results indicate the most profound increases in peak flows due to development are in the more frequent, 2- and 5-year events.

1.5. Hydraulic Analysis

Hydraulic analyses for existing conditions were then conducted for 8 channels within the Haegler Ranch Drainage Basin for the 2-, 5-, 10-, and 100-year recurrence interval floods using the USACE Hydrologic Engineering Center-River Analysis System Version 3.1.3 (HEC-RAS). The hydraulic analysis of Haegler Ranch main stem was performed by dividing the basin into several reaches covering approximately 31 miles from the headwaters near Eastonville Road to its confluence with the unnamed tributary of Geick Ranch Drainage Basin. As part of the field investigation, the size, type, and condition of bridges, culverts, channels, inlets, and pipes were recorded for the existing drainage facilities in the basin.

Using the results of the HEC-RAS modeling, floodplains for the 100-year existing condition flows were delineated. The approximate floodplain and profiles were used to assess where hydraulic inadequacies exist along the major drainageways. The approximate floodplain information was used primarily for the identification of flood prone areas along the major drainageways and to aid in the evaluation of alternative plans. The approximate floodplain data in this DBPS does not replace the information presented in the City of Colorado Springs and El Paso County Flood Insurance studies (FEMA 1999).

1.6. Flooding Problems

Results of the hydraulics analysis show that, of the 22 road crossings in the Haegler Ranch, only 2 crossings can safely pass the existing 100-year flow and 20 road crossings are overtopped. The floodplain areas include approximately 80 residential properties and additional structures.

1.7. Proposed Improvements

Channel improvements and sub-regional detention facilities (designed using "full-spectrum" detention) are proposed to mitigate increased flows due to development and existing erosion issues. The study is not in any way intended to address water rights or other legal issues which may exist with respect to existing private ponds.

Several types of channel improvements are recommended within the basin. In most cases, two alternatives have been called out on the preliminary design sheets. The cost estimate was prepared for the selected sub-regional detention alternative. The regional detention alternative provides optional channel treatments to be considered during final engineering depending upon specific land uses while still providing similar protection. In a few cases channelization is recommended to define and contain the flow where it is currently overland flow in poorly defined, broad, dry-grass swales. Drop structures and grade control are recommended for all channel designs. Hard linings are not recommended due to their expense, maintenance, environmental and hydraulic issues. Drops are preferred to be less than three feet high to enable wildlife to migrate upstream.

1.8. Cost Estimates and Fees

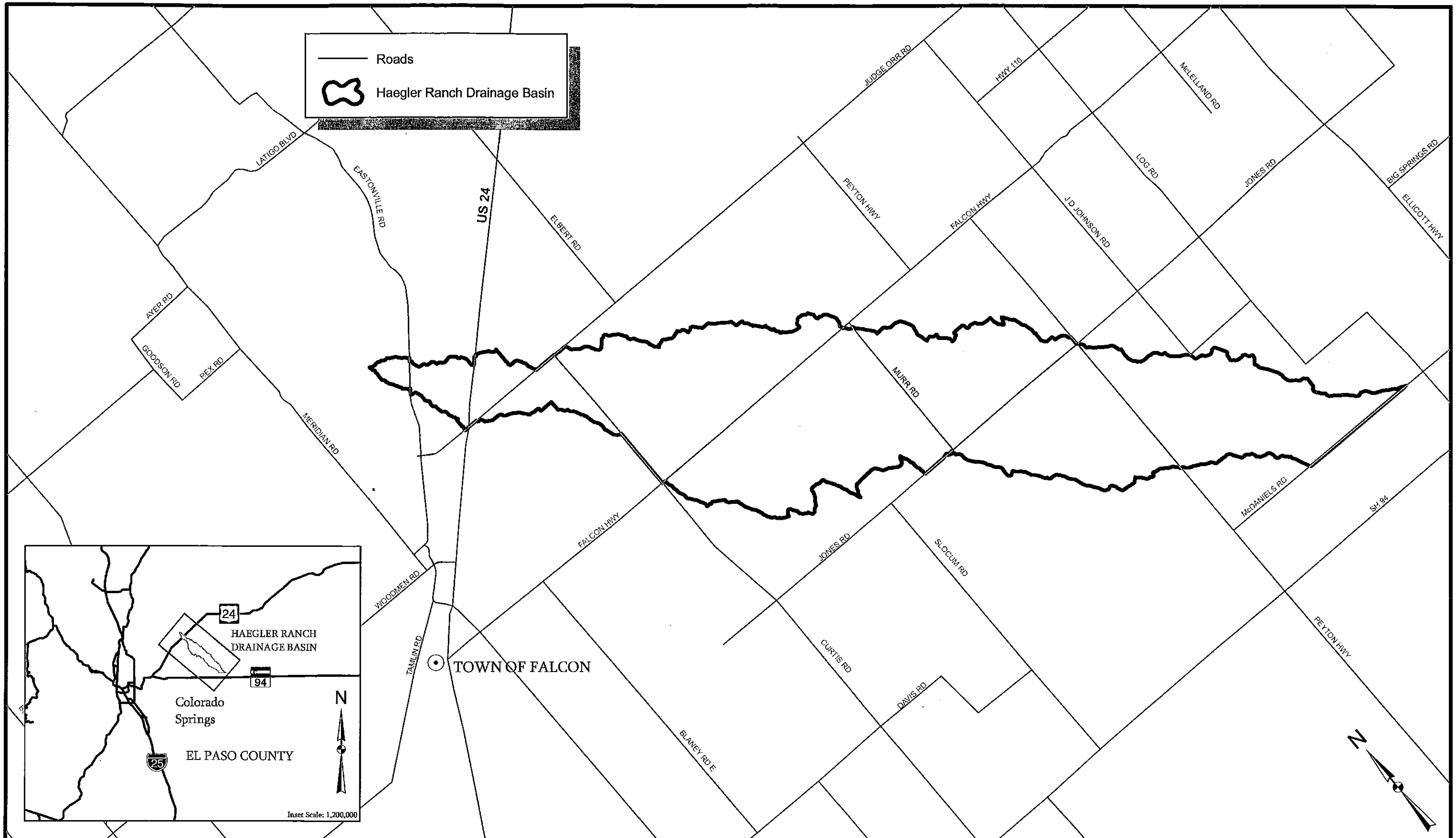
Cost estimates were based on recommended improvements as called out on the preliminary design drawingsof the sub-regional detention alternative. They include 30% construction contingency and 15% engineering contingency. No estimation of costs for local or initial systems has been made.

Fees were calculated on a per impervious acre basis according to the new fee structure adopted by the County September 13, 1999 (DCM 1994). A total of 8,953 acres is estimated to be currently unplatted and subject to future development. This unplatted land is projected to have an average imperviousness of approximately 15%, corresponding to approximately 1,343 unplatted impervious acres. All drainage and bridge fees are calculated per *impervious* acre.

The following table summarizes the total costs for improvements within the Haegler Ranch Basin and the associated fees.

Improvements	Total Cost	Fee per Impervious Acre
Bridges	$1,512,022	$1,126
General Drainage (Including ponds, channels, Falcon town center storm sewer, etc.)	$10,251,636	$7,633
Total	$11,763,658	$8,759

The fee calculation is based upon all ponds, channel improvements and most structures within the Haegler Ranch Basin being funded by drainage fee revenue (see Section 7 for details and calculations). Developers will be required to pay fees and/or construct Haegler Ranch Basin DBPS structures associated with their development. Reimbursement may be requested from the Drainage Board for the cost of DBPS facilities constructed in excess of fees owed by a development. El Paso County may also elect to construct improvements with Haegler Ranch Basin DBPS funds.



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 05/08

HAEGLER RANCH DRAINAGE BASIN

VICINITY MAP
FIGURE 1-1

URS NO. 21711039

2.0 INTRODUCTION

2.1. Purpose and Scope

The purpose of the drainage Basin Planning Study (DBPS) is to identify a stormwater management plan for the existing and future stormwater and infrastructure needs within the Haegler Ranch Drainage Basin (Haegler Ranch). The specific scope of work for this DBPS includes the following tasks:

- Obtain existing relevant data and general information from participating entities.
- Solicit participating entities and other interested agencies or groups regarding alternate plans.
- Obtain current information for land use and future growth in Haegler Ranch.
- Gather information about right-of-way, known drainage problems, and proposed stormwater projects.
- Contact the County, citizens, and other agencies that have knowledge and/or interest in Haegler Ranch.
- Utilize the County policies, criteria, and applicable information wherever possible.
- Perform hydrologic and hydraulic analyses within Haegler Ranch for the 2-, 5-, 10-, and 100-year recurrence interval storm events.
- Identify potential environmental impacts to the Haegler Ranch from growth.
- Identify existing and potential stormwater and/or flooding problems.
- Propose measures to mitigate the impact of stormwater runoff upon environmentally significant areas along the surface waterway(s).
- Develop improvement alternatives to reduce existing and potential flooding problems.
- Examine the operation and maintenance aspects of feasible alternatives.
- Recommend and prepare a preliminary design for a selected alternative plan.
- Conduct an economic analysis of the preferred alternative.
- Develop drainage and bridge fees for Haegler Ranch.
- Prepare a written report discussing all items examined in the DBPS.
- Conduct presentations to public and private entities in order to define project goals and involve entities with specific interest to help define feasible alternatives.

2.2. Summary of Data Obtained

Relevant data were collected as part of this project to construct and complete the required hydrologic and hydraulic models. Data collection included topography, soils, land use, aerial photography, rainfall, and field survey data, along with previous hydrology and floodplain studies. A majority of the data was collected and utilized in a Geographic Information Systems (GIS) format. Local sponsors and government agencies provided the necessary data. Table 2-1 lists the major data collected along with the source:

Table 2-1 Major Data Sources and Data Obtained

Data Source	Data Obtained
Aero-Metric	Digital Terrain Model (DTM) with 2-ft contour intervals, and aerial photographs,
El Paso County	Existing land use, Future land use, and Major Transportation Corridors Plan
Federal Emergency Management Agency (FEMA)	Flood Insurance Studies (FIS), Conditional Letters of Map Revision (CLOMR)
National Oceanic and Atmospheric Administration (NOAA)	Rainfall data
Natural Resources Conservation Service (NRCS)	Soil Survey Geographic (SSURGO) data

In addition to the listed data, reports such as U.S. Army Corps of Engineers (USACE) study of *Black Squirrel Creek, El Paso and Pueblo Counties, Colorado: Hydrologic Analysis* (USACE 2003), City of Colorado Springs, and the County DBPS's were utilized. A number of drainage reports, sketch plans, preliminary and final design drawings, development plans, and existing drainage facility maps were collected from the County and other local agencies. A complete list of reports cited is located in Section 8.0.

Bridges, culverts, and other drainage structures were surveyed in the Haegler Ranch for the hydraulic analysis. Site visits were also conducted at select locations throughout the basin, and photographs were taken documenting the key drainage features.

2.3. Mapping and Surveying

Mapping used in the analysis for Haegler Ranch consists of aerial topographic mapping compiled in April 2004 by Aero-Metric Inc. (AME), AME project number 3040402. The aerial topographic mapping included 2-ft contours and was used in the hydraulic structures inventory (See Section 5.3), hydrologic and hydraulic analyses, and in the alternative planning phases of this project. The vertical datum used is North American Datum 83 (NAD 83).

The following general conditions have been placed upon the use of the aerial topographic mapping:

- Use of these products is restricted to the project for which the Facility Information Management Systems (FIMS) products were provided.
- Only the body content found within the neatline of the borrowed maps may appear in any report/publication developed for the DBPS. Also, the labeling that appears on any photographs provided shall not appear in any such report/publication.
- All FIMS products provided to contractors involved in the subject DBPS shall be retrieved by said department upon conclusion of the DBPS and either returned or destroyed.
- The report(s) developed in which the FIMS products are used shall include the disclaimer statement that is on the Disclaimer page at the beginning of this report.

2.4. Project Coordination

Throughout the course of the DBPS preparation, meetings were held with representatives of the County, State, and Federal agencies as well as adjacent developers, public citizens with an interest in stormwater planning. The primary reason for the coordination effort was to obtain technical information and to identify concerns with regard to the development of stormwater facilities within the Haegler Ranch. The County, State, and Federal agencies were involved in a series of meetings during the development of the alternative planning concepts and the preliminary design for the DBPS. The complete mailing list and project coordination is contained in Appendix E of this report.

2.5. Acknowledgements

During the preparation of the DBPS, several government agencies and interested individuals were routinely involved in the coordination activities. Representatives from the Regional Building Department, NRCS, USACE, and DOT provided valuable commentary during the development of the alternative plans. A list of the individuals and agencies involved on a regular basis during in the preparation of the DBPS is presented below:

Name	Agency
Andre Brackin	El Paso County Department of Transportation
Barbara Dellamand	El Paso County Department of Transportation
Michael Cartmell	El Paso County Department of Transportation
John Valentine	National Resource Conservation Service Colorado Department of Transportation
Kevin Stilson	Regional Building Department, FEMA Colorado Department of Wildlife
Diana Humphries	U.S. Army Corps of Engineers

Additional input was received from the following:

Karen Laden	Black Forest Trails Coalition
	Colorado Geological Survey
	El Paso County Parks Department
	Environmental Protection Agency
	Falcon Area Homeowners' Association
	Federal Emergency Management Agency
	RCI, Inc., Fort Collins, Colorado

3.0 AREA DESCRIPTION

The Haegler Ranch (El Paso County Basin Number CHMS0200) is an unnamed tributary to Ellicott Consolidated Drainage Basin unnamed tributary, which is a tributary of Black Squirrel Creek. Haegler Ranch lies in the central portion of El Paso County. Figure 1-1 shows the location of the Haegler Ranch in respect to El Paso County, Colorado. Haegler Ranch Basin is located in Sections 29, 32 and 33 of Township 12 South Range 64 West and sections 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, 22, 23, and 24 of Township 13 South, Range, 64 West and sections 18, 19, 20, 28, 29, 30, 31, 32, 33, and 34 of Township 13 South, Range 63 West and sections 2, 3, and 4 of Township 14 South, Range 63 West.

3.1. Basin Description

The Haegler Ranch flows to the southeast from north of Eastonville Road to McDaniels Road with a total of 16.6 sq mi in unincorporated El Paso County, Colorado. In 2005, approximately 14% of the basin was developed. Much of the existing development consists of 2- and 5-acre (ac) residential lots surrounded by open space range land used for agriculture and large parcels with homes south of U.S. Highway 24 (US 24). High-density residential developments are being planned in the northern portions of the basin.

The maximum basin elevation is approximately 7,054 ft in the headwaters and falls to approximately 6,085 ft at the downstream confluence of the basin. The basin is typified by rolling rangeland with poor vegetative cover associated with semi-arid climates.

3.2. Climate

This area of El Paso County can be described as high plains with total precipitation amounts typical of a semi-arid region. Winters are generally cold and dry, while the springs and summer receive a majority of this precipitation in the form of rainfall. The average precipitation ranges from 14 to 16 in. per year. Thunderstorms are common during the summer months and are quick-moving low-pressure cells that draw moisture from the Gulf of Mexico into the region. The County has an average temperature ranging from a low of 14°F in the winter to a high of 81°F in the summer. The relative humidity ranges from 25% in the summer to 45% in the winter (SCS 1981).

3.3. Soils and Geology

Soils within the Haegler Ranch are classified according to the NRCS soil classification system. The predominant soils are in the Blakeland soil series, which consist of deep, somewhat excessively drained soils that formed in sandy alluvium and sediment on uplands. The soil series has high infiltration rates, and are extremely susceptible to wind and water erosion where poor vegetation cover exists. Figure 3-1 shows the soil distribution map for the Haegler Ranch (SCS 1981). The bedrock geology is predominately flat lying sandstone and siltstone, some of which is covered with recent alluvium.

3.4. Property Ownership and Land Use Information

Property ownership along the major drainageways within the Haegler Ranch varies from public to private. Along recent developments, drainage right-of-ways and greenbelts have been dedicated during the development of the adjacent residential and commercial land. A portion of Haegler Ranch has already been developed with 2- and 5-ac residential lots. The drainageways in the lower part of the basin remain under private ownership with no delineated drainage right-of-way or easements. A drainage easement or right-of-way must be granted to the County in order for DOT to perform any recommended improvements.

Roadway and utility easements abutting or crossing the major drainageways occur most frequently in the developed portions of the basin. The locations of roadways were obtained from the El Paso County Major Transportation Corridors Plan dated September 21, 2004 (EPC 2004). The El Paso County Rock Island Trail System runs parallel along the north side of US 24. The trail follows the abandoned Chicago and Rock Island Railroad between Falcon and Peyton, Colorado.

Land use information for the existing and future conditions models was obtained from El Paso County Planning Department in 2005. This information is used in the hydrologic analysis to predict runoff rates and volumes for the purposes of stormwater facility evaluation. The identification of land uses abutting the drainageways is also useful in the identification of feasible plans for stabilization and aesthetic treatment of the basin. Presented in Figure 3-2 and Figure 3-3 are the land use maps used for the evaluation of impervious land densities discussed in Section 4.0. These figures are not intended to reflect the future zoning or land use policies of the County.

3.5. Environmental Analysis

An environmental analysis was conducted for this DBPS to assess the present condition of the biological and environmental resources in the Haegler Ranch. Site visits were conducted to study these elements of the basin. Particular attention was paid to the drainageways and spring/seep areas to determine biological resources in riparian zones and wetlands.

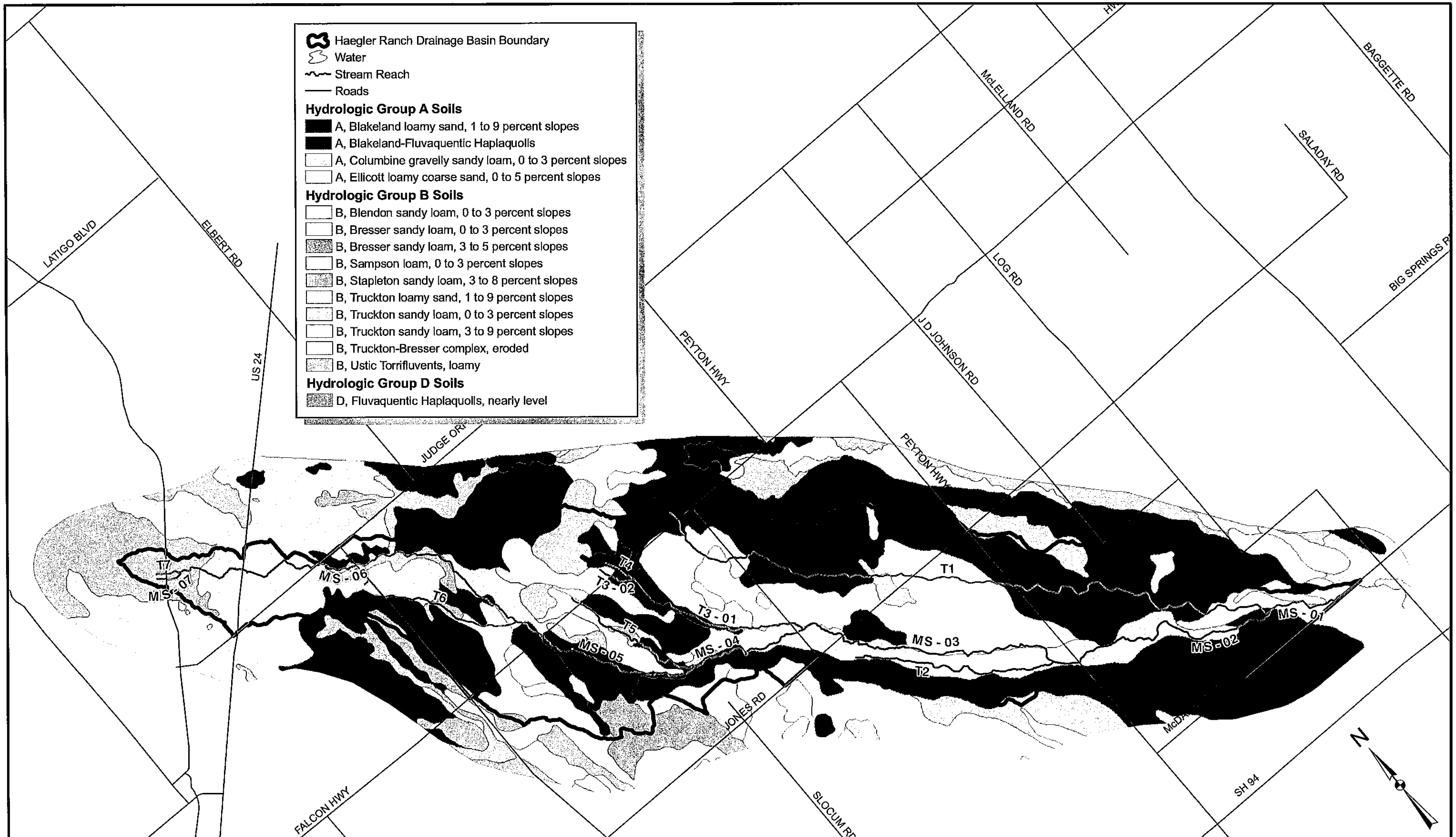
The Haegler Ranch consists of indistinct ephemeral streams that flow after storms for a short period of time. The main stem of Haegler Ranch consists of dry natural grass swales with some poor quality riparian zones and small wetlands in the floodplains. Most of the wetlands surround stock reservoirs and are heavily grazed in some of the rangeland pastures. As a result, the wetlands and riparian drainageways have been degraded in vegetative cover and ecological value. The existing wetlands are neither large nor extensive, and are mostly discontinuous. In their present condition, the wetlands are not a significant habitat resource within the basin. Figure 3-4 and Figure 4-4 show and potential wetlands that may require further study.

Most of the open space is used for agriculture or rangeland. Drainageways have been channelized principally only at roadway crossings. These areas of concentrated flow have defined channels that tend to become indistinct as they flow downstream. Vegetation in the Haegler Ranch in the open space does not vary dramatically. Vegetation patterns generally follow the physiographic region of the plains dominated by a short- to mid-height prairie grass with a few shrubs and sporadic trees such as cottonwoods. Wetlands consist of rushes and sedges such as little bluestem, grama grasses, needle and thread and western wheat grass.

Wildlife and animal species common to the open plains inhabit the basin. They consist of animals that tolerate the presence of roads and people including large and small mammals such as deer, antelope, coyotes and rodents, and several species of birds such as killdeer and red-winged blackbirds. Preliminary review indicates that the DBPS will not affect any threatened or endangered species or critical habitat.

Because of the sensitivity of wetlands, riparian areas, and wildlife to stormwater runoff, sedimentation and erosion should be evaluated and planned for in the alternatives. Wetland and riparian areas provide a habitat resource that should be preserved during the alternative development. These areas can be protected and enhanced to improve ecological value.

This page intentionally left blank



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

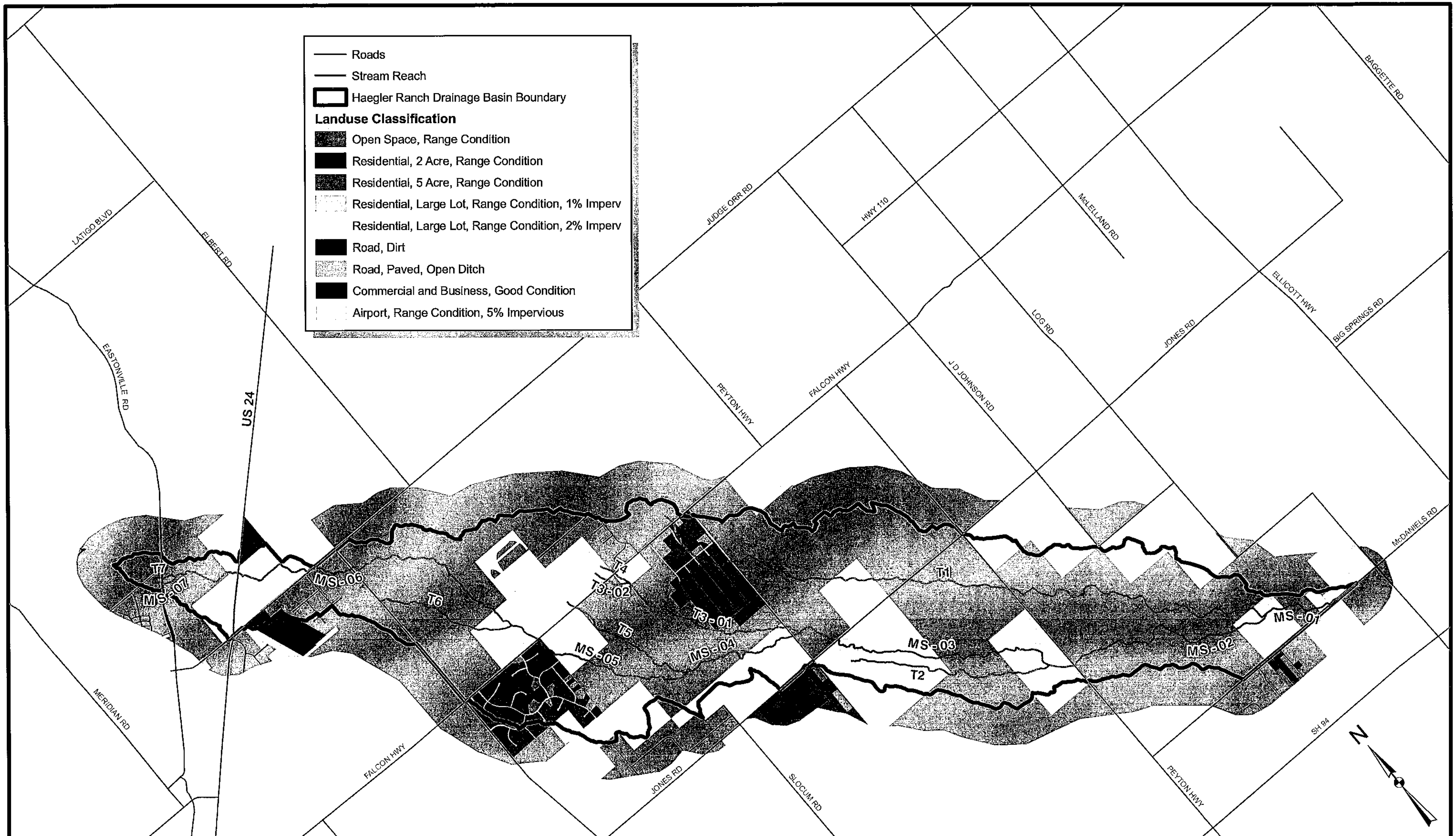
5,000 2,500 0 5,000 Feet
1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

SOILS
FIGURE 3-1

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

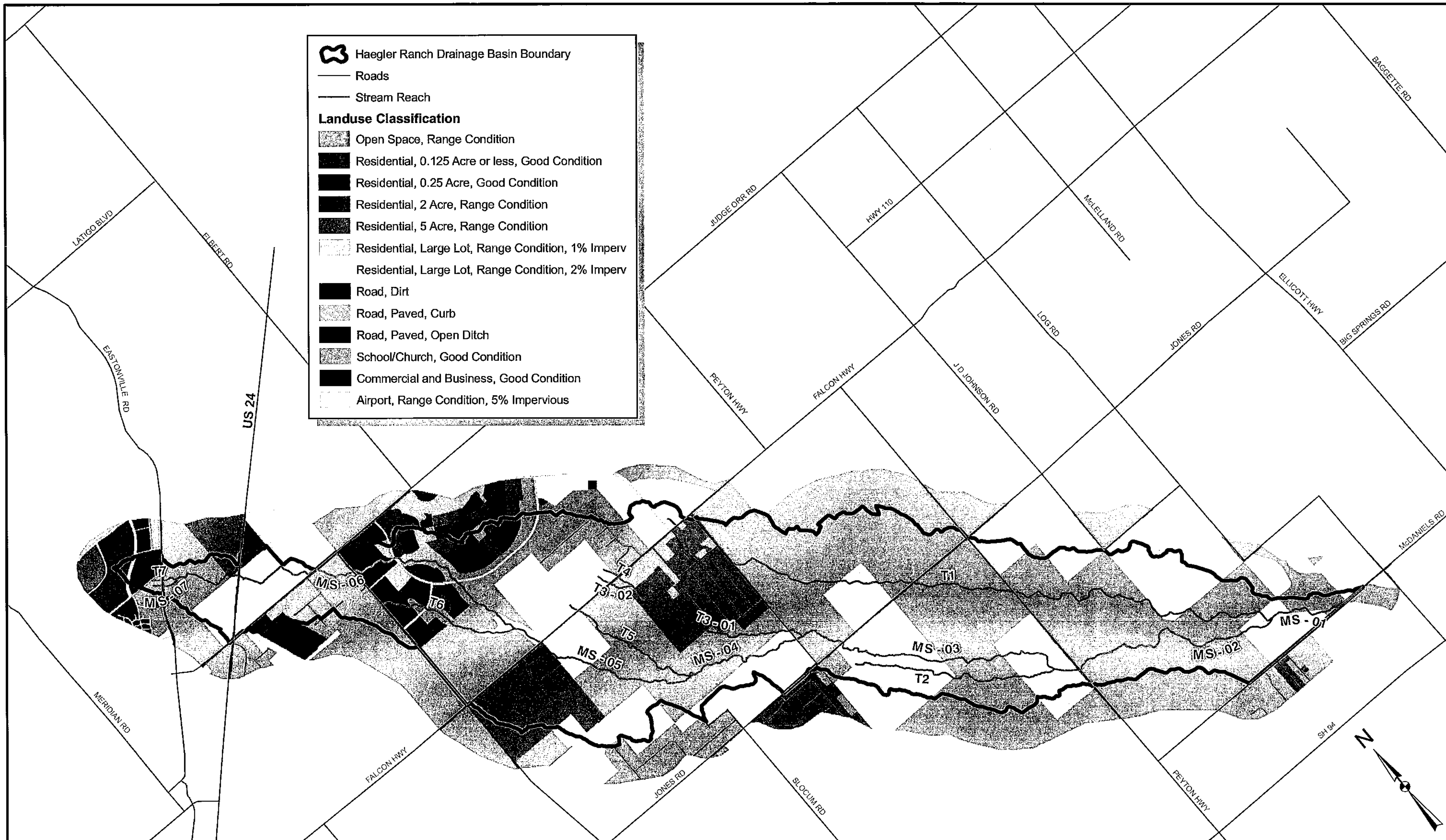
5,000 2,500 0 5,000 Feet
1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

EXISTING LAND USE
FIGURE 3-2

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

5,000 2,500 0 5,000 Feet

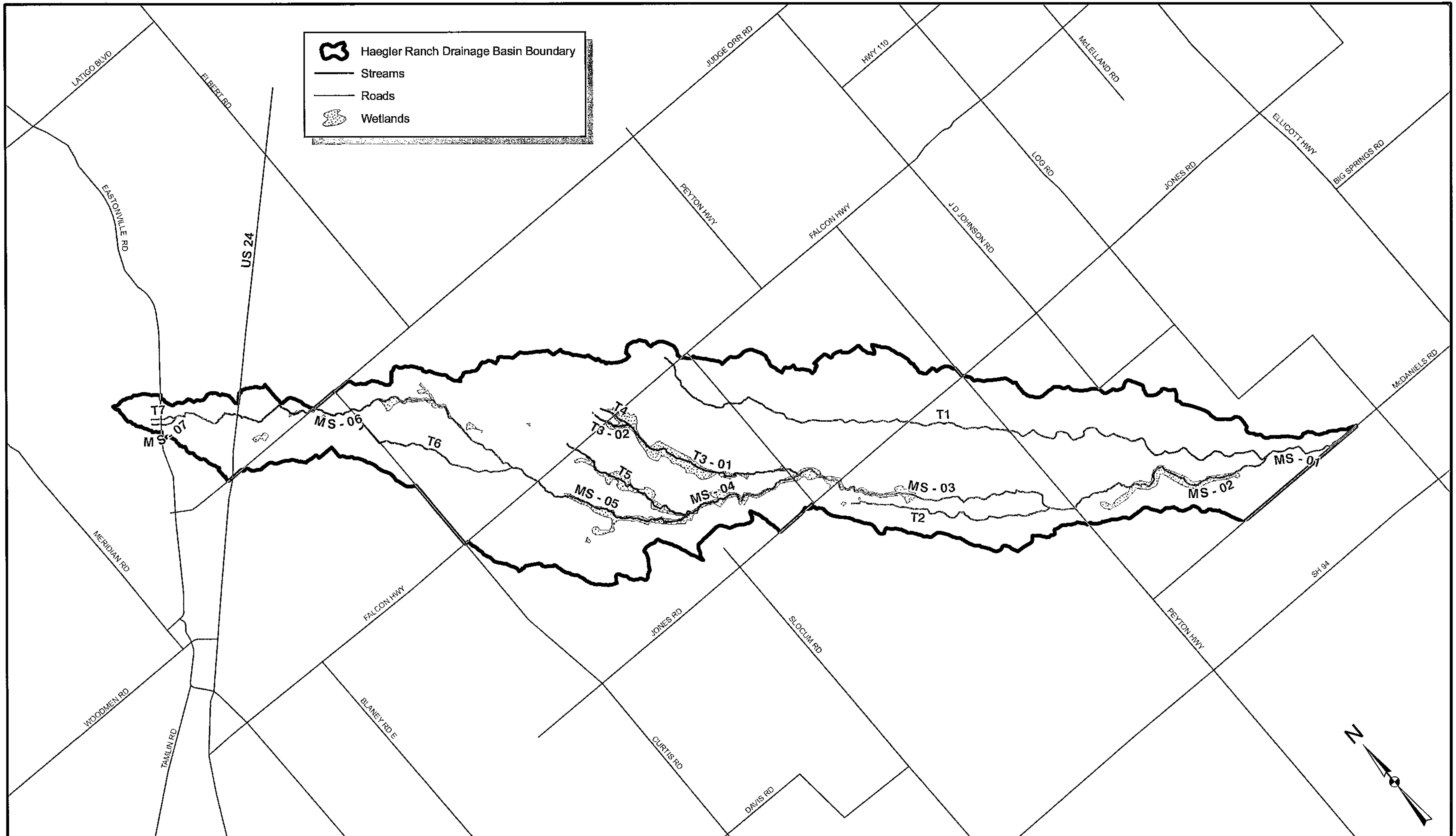
1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

FUTURE LAND USE
FIGURE 3-3

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

5,000 2,500 0 5,000 Feet

1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

WETLANDS
FIGURE 3-4

URS NO. 21711039

4.0 HYDROLOGIC ANALYSIS

4.1. Project Basin

Hydrologic analyses for existing and future conditions were computed for the 68 subbasins within the Haegler Ranch for the 2-, 5-, 10-, and 100-year recurrence intervals. Sub-basin delineations and study reaches are shown in Figure 4-1.

The main stem in the Haegler Ranch is an unnamed tributary located within the Chico Creek basin in central El Paso County, Colorado. The Haegler Ranch's headwaters are on the southeastern slope of the Black Forrest. The main stem flows to the southeast in the eastern plains of the County to the confluence with Geick Ranch Drainage Basin north of Ellicott. Bennet Ranch and Solberg Ranch Drainage Basins bound the Haegler Ranch to the west, Geick Ranch Drainage Basin to the east, and Telephone Exchange and Ellicott Consolidated Drainage Basins to the south. The Haegler Ranch has a contributing drainage area of approximately 16.6 sq mi at its confluence with the Geick Ranch Drainage Basin on the north side of McDaniels Road.

A portion of the original Haegler Ranch as delineated by the County map was found to be part of the Geick Ranch Drainage Basin at Judge Orr Road, due to the lack of a roadway culvert, as seen in Figure 4-1. This area is excluded from the Haegler Ranch DBPS and is included as part of the Geick Ranch DBPS, per the County.

4.2. HEC-HMS Modeling

Hydrologic modeling was completed using the USACE Hydrologic Engineering Center – Hydrologic Modeling System Version 2.2.2 (HEC-HMS). Each component of this model is described in detail following this section. A geospatially referenced basin model was generated in the USACE Hydrologic Engineering Center – Geospatial Hydrologic Modeling System Extension Version 1.1 (HEC-GeoHMS). Using HEC-GeoHMS, subbasin and stream reach physical characteristics including area, longest hydraulic flowpath, reach length, slope, and topological connectivity were extracted for calculation of hydraulic parameters such as time of concentration. Hydrologic parameters were calculated as outlined below and automatically populated to the basin and meteorological components of the HEC-HMS model. A summary of selected methodologies for each HEC-HMS model component is provided in Table 4-1.

Table 4-1 HEC-HMS Model Components

Model Component	Selected Methodology
Meteorological Model	User Gage Weighting Method
Infiltration Loss	SCS Runoff Curve Number Method
Runoff Transformation	SCS Unit Hydrograph Method
Channel Routing	Muskingum-Cunge Standard Method

Notes:
HEC-HMS = U. S. Army Corps of Engineers Hydrologic Engineering Center – Hydrologic Modeling System
SCS = Soil Conservation Service (since renamed NRCS)

The User Gage Weighting Method was chosen to model the Type IIa storm based on the City of Colorado Springs and El Paso County Drainage Criteria Manual (DCM) (1991). The Soil Conservation Service (SCS) Type IIa 24 hour hypothetical rainfall distribution was imported into the HEC-HMS precipitation gage manager. Rainfall depths for each subbasin were then entered in the meteorological model. Rainfall was modeled with an areal reduced uniform spatial distribution based on the size of the basin.

Infiltration and runoff volumes were modeled using the SCS (now renamed NRCS) Runoff Curve Number (runoff CN) Loss Method. The composite runoff CN was calculated for each subbasin and imported into HEC-HMS. For modeling purposes, initial infiltration loss rates were automatically calculated as functions of composite runoff CNs by HEC-HMS.

The transformation of runoff volume to a runoff hydrograph was modeled using the SCS Unit Hydrograph Method. Subbasin lag times were calculated from the time of concentration as computed using the method outlined in the DCM.

The Muskingum-Cunge Method was selected to develop the channel routing component of the HEC-HMS model. This method was chosen to represent the travel time in the channel because it is based on channel physical measurements such as width, depth, and slope. Channel dimensions and Manning's roughness coefficients (n values) were imported into HEC-HMS.

4.3. Basin Delineation

Basin delineation and stream network definition were completed in an ArcView® GIS environment using HEC-GeoHMS. The subbasin boundaries and stream network were refined using 2-ft contours, aerial photography, field survey, and site visit data.

The Haegler Ranch was divided into 68 subbasins with areas ranging from 0.02 sq mi up to 0.65 sq mi, as seen in Figure 4-1 and Figure 4-4. Subbasin slopes range from 0.16% to 8.0%. Subbasins were delineated at tributaries, major road crossings, changes in slope, and other drainage features. For the SCS Runoff CN Loss Method, the subbasins should be larger than 0.156 sq mi (100 ac) if possible. For some areas, the subbasins are smaller to accurately represent road crossings or detention. A schematic of the connectivity of the subbasins, junctions, and reaches can be seen in Figure 4-5.

4.4. Hydrologic Soil Group

Soils are classified into hydrologic soil group (HSG) by the NRCS for hydrologic modeling. HSG is a parameter assigned to each soil series by the NRCS to reflect the relative rate of infiltration of water into the soil profile. NRCS *Technical Release 55* (*TR-55*) (1986) defines HSG into A, B, C, and D as follows:

HSG A - soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission.

HSG B - soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

HSG C - soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission.

HSG D - soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

The HSG was determined for each of the soil mapping units from the NRCS SSURGO for the County, as seen in Figure 3-1. Three HSGs are found within the Haegler Ranch. Group A soils, with moderate to high infiltration rates, dominate the basin at 56% coverage. Almost all of the soils in Haegler Ranch are in HSGs A and B with moderate to high infiltration and low runoff. In undeveloped areas, the predominance of HSG A and B soils give this basin a lower runoff per unit area as compared to basins with soils dominated by HSG C and D. Table 4-2 provides statistics for the HSGs within the basin.

Table 4-2 HSGs within the Haegler Ranch Drainage Basin

HSG	Basin Coverage (%)
A	56%
B	43%
C	0%
D	1%

Notes:
HSG = Hydrologic Soil Group
% = percent

4.5. Land Use

Land use information for the Haegler Ranch was obtained from the County. Both existing (circa 2005) and future (circa 2030) land use data were obtained from the County in GIS format. Each land use class was assigned a corresponding NRCS land use and condition class based on the *TR-55* and *Procedures for Determining Peak Flows in Colorado* (SCS 1984).

The Haegler Ranch reflects a variety of existing land uses including residential (high, medium, and low density), commercial and business, open space and rangeland, and roads. The predominate land use is open space with a mixture of vacant land, agriculture, and rangeland. Due to growth in the basin, land use is expected to change in the future conditions with new low and medium density residential developments.

Two major proposed developments in Haegler Ranch are Meridian Ranch in the north and Santa Fe Springs in the central portion of the watershed. The area of Meridian Ranch that is within Haegler Ranch has high density land uses of commercial and business, residential lots of 0.25 acres, and roads with curb and gutter. Santa Fe Springs has a larger area in Haegler Ranch and a wider range of land uses including high density development such as commercial and business, residential lots of 0.125 acres, residential lots of 0.25 acres, schools, and roads with curb and gutter as well as low density development such as residential large lots with 2% imperviousness, parks, and open space.

URS assigned 13 NRCS *TR-55* land use and condition classes within the Haegler Ranch for the existing and future conditions model, as seen in Figure 3-2 and Figure 3-3. Open Space, range condition was the dominant land use in the basin at 60% coverage in existing conditions and 46% coverage in the future conditions. In the future conditions model, the Haegler Ranch will have residential development in the upper and middle portions of the basin. A summary of land use classes is provided in Table 4-3.

Table 4-3 Major Land Use Classes within the Haegler Ranch Drainage Basin

Assigned NRCS Land Use and Condition	Existing Basin Coverage	Future Basin Coverage
Open Space, Range Condition	60%	46%
Residential, Large Lot, Range Condition, 2% Impervious	16%	16%
Residential, Large Lot, Range Condition, 1% Impervious	11%	10%
Residential, 2 ac, Range Condition	6.7%	9.1%
Residential, 5 ac, Range Condition	4.6%	9.5%
Road, Paved, Open Ditch	1.6%	1.7%
Road, Dirt	0.54%	0.48%
Commercial and Business, Good Condition	0.36%	2.7%
Airport, Range Condition, 5% Impervious	0.01%	0.01%
Residential, 0.25 ac, Good Condition	0%	2.8%
Residential, 0.125 ac or less, Good Condition	0%	0.59%
Road, Paved, Curb	0%	0.52%
School/Church, Good Condition	0%	0.22%

Notes:
% = percent
ac = acre

This report was presented to the El Paso County Planning Commission on February 3, 2009. The Planning Commission requested that the Falcon Small Area Master Plan (SAP) land use be compared with 2005 land use data used in this study. URS prepared an evaluation of the SAP and presented it to the Planning Commission at their meeting on May 7, 2009. The comparison of the SAP to the future land use assumptions used in this study is in Appendix G.

4.6. Runoff Curve Number Development

Runoff CN is a parameter developed by the NRCS to quantify the relationship between rainfall, infiltration, and runoff. It represents the combination of a HSG and a land use class and condition (McCuen 1998). Runoff CNs are estimated as a function of land use, HSG, and antecedent moisture condition (AMC). URS assigned runoff CNs for each class based on the *TR-55* land use/runoff CN table and *Procedures for Determining Peak Flows in Colorado* (SCS 1984) as seen in Figure 4-2 and Figure 4-3.

Table 4-4 Runoff Curve Numbers for Haegler Ranch Drainage Basin

Land Use and Hydrologic Condition	Average % Impervious Area	Use HSG B for Regraded HSG A	Runoff Curve Numbers for HSG			
			A	B	C	D
Impervious Area and Water	100%	No	98	98	98	98
Open space (lawns, parks, golf courses, etc.)[1]:						
Poor Condition (grass cover <50%)	0%	No	68	79	86	89
Range Condition (grass cover ≈ 40%)	0%	No	58	73	82	86
Fair Condition (grass cover 50% to 75%)	0%	No	49	69	79	84
Good Condition (grass cover >75%)	0%	No	39	61	74	80
Roads:						
Dirt	55%	Yes	72	82	87	89
Paved; Open Ditches	75%	Yes	83	89	92	93
Paved; Curb & Storm Sewer	100%	Yes	98	98	98	98
Good Condition[2]:						
Urban Districts:						
Commercial and Business	85%	Yes	89	92	94	95
School/Church	65%	No	77	85	90	92
Residential districts by average lot size:						
1/8 ac or less (multifamily)	65%	Yes	77	85	90	92
1/4 ac	38%	Yes	61	75	83	87
1/3 ac	30%	Yes	57	72	81	85
1/2 ac	25%	Yes	54	70	80	85
Range Condition[2]:						
Urban Districts:						
Airport	5%	Yes	60	74	83	87
Residential districts by average lot size:						
1 ac	20%	No	66	78	85	88
2 ac	12%	No	63	76	84	87
5 ac	5%	No	60	74	83	87
Large (160 ac, two or three structures)	2%	No	59	74	82	86
Large (160 ac, single structure)	1%	No	58	73	82	86

Notes:
% = percent
HSG = Hydrologic Soil Group
ac = acre
[1] Range Cover of 40% is based on field observations and discussions with the County. The selected curve numbers based on Figure S-3 from "Procedures for Determining Peak Flows in Colorado" by Soil Conservation Service, March 1984. Based on Figure S-3 and the *TR-55* CN Table, poor condition is 15% cover, fair condition is 55% cover, and good condition is 85% cover.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space with the respective hydrologic condition.

The runoff CN for urban residential developments smaller than 1 ac, multifamily homes, commercial and business sites with good conditions for the pervious area based on regrading, irrigation, and lawn maintenance was taken directly from the DCM. For residential areas 1 ac and larger, the pervious area was considered range condition based on large lots that will only have a small percentage of the lot irrigated. For the large residential lots with range condition pervious areas, the runoff CN was calculated based on Figure 2-3 from the *TR-55* manual. The composite runoff CN is calculated as the percent pervious multiplied by a pervious runoff CN, plus the percent impervious multiplied by the pervious runoff CN for open space, range condition.

Runoff CNs were developed for both existing and future conditions within the Haegler Ranch. Any areas in HSG A that have been regraded as part of development were calculated as HSG B for runoff CNs.

Within an ArcMap® GIS environment, discrete combinations of soil mapping units and land uses were developed. Assuming average AMCs, runoff CNs were determined for each unique soil/land use combination using runoff CNs in Table 4-4. A runoff CN grid for the entire basin was then developed for both the existing and future conditions, as shown in Figure 4-2 and Figure 4-3. Using HEC-GeoHMS, composite runoff CNs were calculated and assigned to each subbasin.

The overall runoff CN for the basin is expected to increase between the existing and future conditions with an area-weighted average of 66 and 68, respectively. The changes in future land use are concentrated to two major developments, Meridian Ranch in the north and Santa Fe Springs in the central portion of the watershed. Runoff CNs for the basin are summarized in Table 4-5.

Table 4-5 Runoff Curve Number Summary for the Haegler Ranch Drainage Basin

	Existing Runoff CN	Future Runoff CN
Minimum	58	58
Maximum	98	98
Average	66	68

Notes:
Runoff CN = runoff curve number

4.7. Time of Concentration

The time of concentration was calculated by summing the travel time for overland sheet flow, shallow concentrated flow, and channel flow segments along the longest flowpath as outlined in *TR-55*. The longest flow path was automatically delineated using HEC-GeoHMS, and then the longest flow paths were manually modified where appropriate to match the drainage patterns in the subbasins based on roads and culvert crossings. Overland flow was assumed to occur within the first 300 ft and may end before 300 ft if development is encountered, based on the *TR-55*. Shallow concentrated flow occurs after 300 feet of overland flow. Channel flow occurs after shallow concentrated flow when a channel is apparent in the aerial photo or contours, which transports runoff to the outlet of the subbasin.

Times of concentration calculations were completed for each of the 68 Haegler Ranch subbasins using sheet and channel flow segments. A summary of the time of concentration values for the Haegler Ranch is provided in Table 4-6.

Table 4-6 Time of Concentration Summary for the Haegler Ranch Drainage Basin

	Time of Concentration (min)	
	Existing	Future
Minimum	21	5
Maximum	119	119
Average	50	42

Notes:
min = minutes

For the future conditions model, the time of concentration was adjusted for development. Overland flow was decreased in developed areas based on the type and density of future development. Shallow concentrated flow was shortened or eliminated based on the proposed development. Channel flow occurs after overland flow in a manmade channel. Future development typically decreases the time of concentration. However, future development can be planned to mimic current drainage patterns and employ methods to increase travel times to reduce peak flows.

4.8. Channel Routing

The Muskingum-Cunge method was used for hydrograph channel routing in 57 channel reaches in the Haegler Ranch. A shallow grass lined channel is dominant in the majority of the basin. Some portions of the basin have been channelized in developments or along roads. Table 4-7 lists the channel characteristics in the Haegler Ranch.

Table 4-7 Channel Characteristics in the Haegler Ranch Main Stem

	Slope (%)	Manning's Roughness Coefficients
Minimum	0.58	0.025
Maximum	2.70	0.055
Average	1.20	0.049

Notes:
% = percent

4.9. Climate and Precipitation

A hypothetical rainfall event was used to simulate precipitation for hydrologic analyses. The NRCS Type IIa 24-hour storm distribution is recommended for temporal distribution in the DCM. Storm events with 2-, 5-, 10-, and 100-year recurrence intervals were selected for hydrologic modeling. These storm events have an equivalent of a 50-, 20-, 10-, and 1-percentage chance of exceedance, respectively.

Isopluvial maps published in *NOAA Atlas 2* (Miller et al. 1973) were used to estimate rainfall in the Haegler Ranch for each recurrence interval. Within an ArcMap® GIS environment, rainfall grids were developed for each recurrence interval from isopluvial contours. Using HEC-GeoHMS, rainfall depths for the 24-hour storm duration were calculated and assigned to each subbasin. Since the basin is greater than 10 sq mi, an areal reduction factor was applied as prescribed by *NOAA Atlas 2*.

The NRCS Type IIa 24-hour hypothetical rainfall event, with uniform spatial distribution, was used to simulate precipitation within the Haegler Ranch. Based on the basin area of 16.6 sq mi, an areal reduction of 2% was applied to the *NOAA Atlas 2* rainfall depths for each recurrence interval modeled. Table 4-8 provides the 24-hour rainfall depths for each recurrence interval.

Table 4-8 Rainfall Depths within the Haegler Ranch Drainage Basin

Recurrence Interval	Rainfall Depth (in.)[1]
2-year	1.96
5-year	2.55
10-year	2.94
100-year	4.51

Notes:
[1] Areal reduction of 2% applied to rainfall depths from the *NOAA Atlas 2*.
in. = inches

4.10. Storage and Groundwater

In Haegler Ranch, some storage may occur in ponds and high groundwater can affect some storm events. For Haegler Ranch, storage occurs in stock ponds, low spots, and retention ponds. Based on field visits, these areas do not have an outlet structure or routine maintenance, so all these areas are considered full for hydrologic modeling in the DBPS.

Groundwater is a concern in this area of El Paso County based on flooding in previous storm events. The groundwater level can be high and can have a large affect on even a small storm event if the ground water table is saturated. Moisture conditions were taken as Antecedent Moisture Condition II from the *TR-55*. This is modeled as having a 5-year storm 5 days before the modeled storm event. This is standard engineering practice for the Front Range and the recommendation of the *DCM*. If multiple storm events occur in a short period of time, a minor rainfall event may produce a major runoff event. Studying the groundwater affects due to recent storms is typically done for specific rainfall events and not to model the typical flooding patterns of planning studies.

4.11. Validation

In the Haegler Ranch, no U.S. Geological Survey (USGS) gages are available for calibration. In order to validate the model, the DBPS hydrologic flows were compared to five methods including regional regression equations, a flow curve, a previous study, and a composite basin calculation. Results are listed in Table 4-9. The first regional regression equation was from the USGS in Analysis of the Magnitude and Frequency of Floods in Colorado (USGS 2000). The second regional regression equation was from the Colorado Water Conservation Board (CWCB) in Guidelines for Determining 100-year Flood Flows for Approximate Floodplains in Colorado (CWCB 2004). The third source is from the Urban Drainage and Flood Control District (UDFCD) in Denver and uses a flow curve based on 42 gaged sites in the Plains Region. The fourth source for comparison was from the USACE study of Black Squirrel Creek El Paso and Pueblo Counties Colorado: Hydrologic Analysis (USACE 2003). The fifth method was to make a composite basin of the entire Haegler Ranch using the weighted average runoff CN and a total time of concentration.

Table 4-9 Flood Summary Comparison for the Haegler Ranch Drainage Basin

Annual Percent Chance Flood Event	Recurrence Interval	Peak Flow (cfs)						
		Existing Conditions DBPS Model	Future Conditions DBPS Model	USGS Regression Analysis, Plains Region[1]	CWCB Regression Analysis, ARK - 5[2]	FEMA / UDFCD Gages[3]	USACE Black Squirrel Creek Model[4]	Haegler Ranch Drainage Basin Composite Basin[5]
50%	2-year	190	550	150	---	---	360	96
20%	5-year	570	1,300	600	---	---	1,200	270
10%	10-year	950	2,000	1,100	---	---	1,900	420
1%	100-year	3,200	5,600	4,900	6,800	7,200	5,000	1,200

Notes:
cfs = cubic feet per second
% = percent
DBPS = Drainage Basin Planning Study
USGS = U.S. Geological Survey
CWCB = Colorado Water Conservation Board
FEMA = Federal Emergency management Agency
UDFCD = Urban Drainage Flood Control District
USACE = U.S. Army Corps of Engineers
[1] USGS Regression Analysis equations are from "Analysis of the Magnitude and Frequency of Floods in Colorado" Water-Resources Investigations Report 99-4190. The Plains Region covers the eastern plains below an elevation of about 9,000 ft. Drainage areas for the study ranged from 5 to 1,000 sq mi.
[2] CWCB Regression Analysis equations are from "Guidelines for Determining 100-Year Flood Flows for Approximate Floodplains in Colorado" by the Department of Natural Resources Colorado Water Conservation Board, June 2004. ARK-5 includes the Chico Creek basin with the boundary along the eastern boundary of the basin. Equations are only valid for tributaries between 4 and 75 sq mi.
[3] Tabulation of 42 stream gages in the Plains Region for the Urban Drainage and Flood Control District (UDFCD) in Denver that was provided by FEMA.
[4] "Black Squirrel Creek El Paso and Pueblo Counties Colorado: Hydrologic Analysis" study by USACE 2003.
[5] Composite Basin for in HEC-HMS using the area-weighted average runoff CN and total time of concentration.

The existing condition flows for the DBPS hydrologic model are lower than the USGS regression analysis, CWCB regression analysis, UDFCD gages, and USACE Black Squirrel Creek Model, but the flows are higher than the composite basin for Haegler Ranch. Assumptions and applicability of each method are as follows:

- USGS Regression Analysis, Plains Region
  - Uses area as only input parameter
  - Does not account for rainfall, basin slope, or soil type
  - Based on very limited gaging station in eastern plains and none within the Black Squirrel Creek basin
  - Margin of error is 300% for 100-year storm event
- CWCB Regression Analysis, ARK-5
  - Uses area as only input parameter
  - Does not account for rainfall, basin slope, or soil type
  - Based on study results and not gage data
- FEMA/UDFCD Gages
  - Uses rainfall, area, and basin shape
  - Based on regional characteristics including Kansas
  - Not specifically intended for Colorado
- USACE Black Squirrel Creek Model
  - Uses State Soil Geographic (STATSGO) database which is generalized soil data
  - Based on regression equation to calculate lag time
  - Employs SCS Type II storm
  - Obtained landue from National Land Cover Dataset (NLCD) circa 1992
  - Uses higher imperviousness for existing low density development (20-30%)
  - Delineated basins and stream from 20-ft contours for a basin area of 18.8 sq mi
- Haegler Ranch Drainage Basin Composite Basin
  - Merges subbasins form DBPS into one large basin
  - Uses TR-55 to calculate lag time from the top of the basin along the river to confluence with Geick Ranch
  - Averages curve number from DBPS

The USGS regional regression equation flows are about 50% higher than the flows from the DBPS, but these regression equations have a large standard error. The CWCB regression equation flow is more than twice as high as the DBPS flow. Both regression equations have higher flows than the DBPS and neither regression analysis accounts for high rates of infiltration that occur in Haegler Ranch.

As part of a large basin study, the USACE Black Squirrel Creek Study (Black Squirrel) modeled the flow for the Haegler Ranch. The flows from the Black Squirrel model are higher than the flows for the DBPS. This is due to assumptions made in both models. Black Squirrel used 20-ft contours while the DBPS used 2-ft contours to delineate subbasins. Black Squirrel used National Land Cover Dataset (NLCD) data based on satellite imagery circa 1992 while the DBPS used existing data form the County. Black Squirrel used a regression equation to calculate the lag time while the DBPS used channel measurements. Black Squirrel used the initial abstraction for calibration of the large basin while the DBPS used uncalibrated flows with no gage data. The scale of the models also affects these flows. Black Squirrel is 724 sq mi while the DBPS is only 16.6 sq mi.

The Haegler Ranch composite basin was modeled using the average runoff CN of 66 and a total lag time of 376 minutes. The lag time was calculated based on 300 ft of overland flow, followed by shallow concentrated flow, and channel flow from the upper portions of the basin to the confluence. The channel slope and Manning's roughness coefficients for the channel are the average values for each, 1.20% and 0.49 respectively. All recurrence interval flows for the composite basin model are less than the existing conditions DBPS model. This is due to lack of detail since the subbasins and flows are not routed throughout the basin.

The existing condition DBPS modeled flows are higher than the regional regression equations, the flow curve from gage data, and the Black Squirrel Creek study. Due to existing development and the methodology used to develop the other methods, the flows vary. Due to differences and reliability of the comparisons, no action was taken to calibrate the DBPS model.

4.12. Results

Peak flows for all the subbasins, reaches, and junctions calculated throughout the Haegler Ranch are shown in Figure 4-4. HEC-HMS models for existing and future basin conditions are in Appendix A.

The existing flows were based on the existing routing, existing runoff CNs, and existing time of concentrations. For the future condition flows, the routing, runoff CNs, and times of concentrations were adjusted for future land use. The future conditions model does not currently take into account any proposed detention, channelization, or alternative configurations.

Summarized in Tables 4-10 and 4-11 are a comparison of peak flows and volumes at key locations throughout the Haegler Ranch for both existing and future models. The largest flow and volume increases occur in the middle portion of the basin in response to development. These flows and volumes are based on no detention. There is planned detention upstream per the approved Master Development Drainage Plans (MDDPs) within this area that will be reevaluated during design.

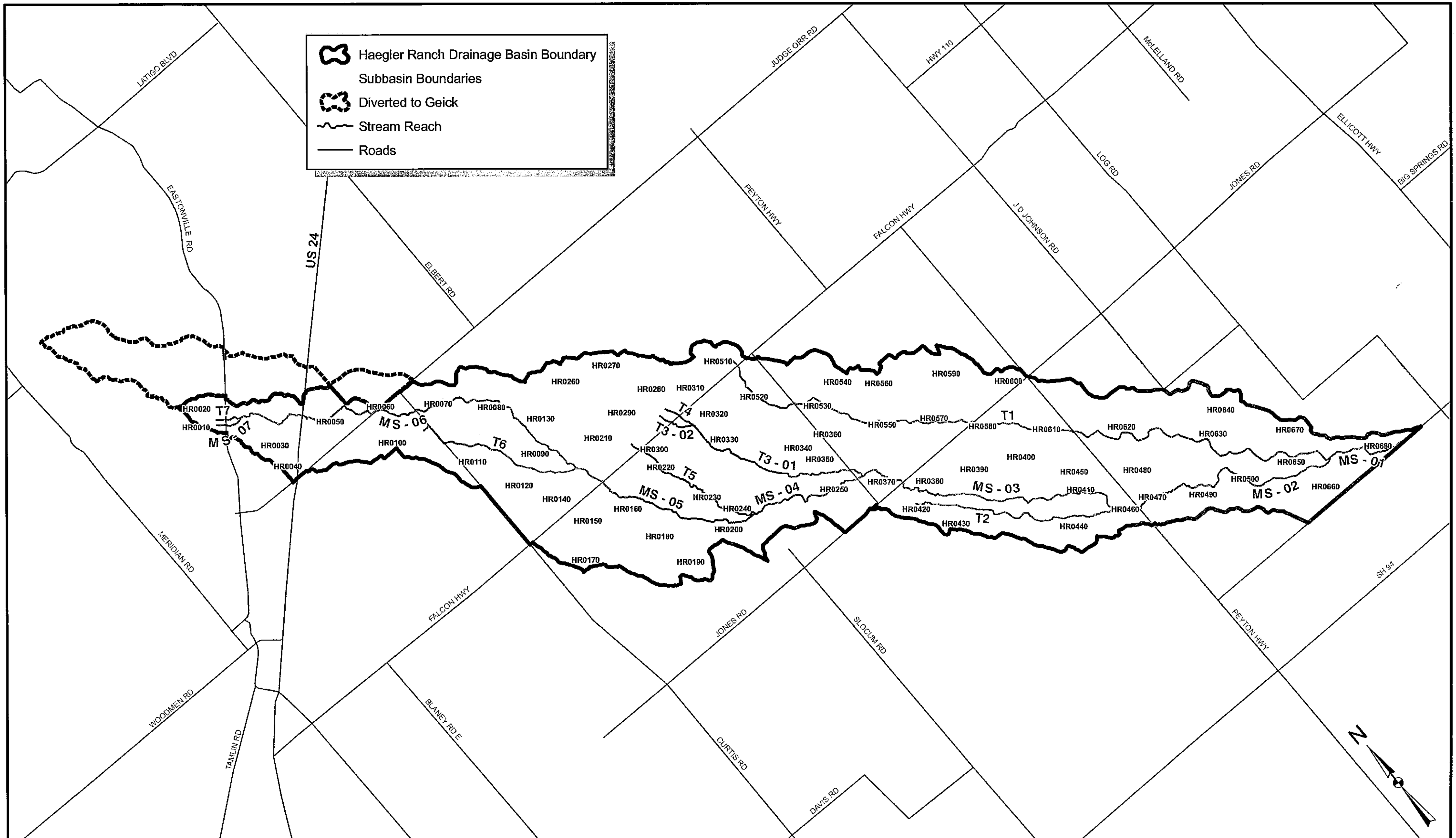
The mainstem and southeast tributary experience an increase in flows throughout the watershed as a result of development. The change in peak flows decreases as water moves downstream because peak flows are attenuated and development does not occur in the lower portion of the watershed.

Table 4-10 Reach Flow Comparison for the Haegler Ranch Drainage Basin

Key Location	HEC-HMS Element	Area (sq mi)	Existing Flows (cfs)				Future Flows (cfs)				Future Flows Increase (%)			
			2-yr	5-yr	10-yr	100-yr	2-yr	5-yr	10-yr	100-yr	2-yr	5-yr	10-yr	100-yr
Main stem at US 24	JHR0030	0.5	21	65	110	350	120	210	280	630	471%	223%	155%	80%
Main stem at Judge Orr Road	JHR0056	0.9	24	85	150	540	120	230	330	830	400%	171%	120%	54%
Main stem at Falcon Highway	JHR0145	3.3	39	150	280	1,100	420	790	1,100	2,400	977%	427%	293%	118%
Main stem at Jones Road	JHR0370	8.6	150	420	670	2,300	600	1,300	1,900	5,000	300%	210%	184%	117%
Main stem at Peyton Highway	JHR0465	10.7	180	490	790	2,600	570	1,300	2,000	5,400	217%	165%	153%	108%
Southeast Tributary at Jones Road	JHR0570	1.8	29	75	120	370	48	120	180	520	66%	60%	50%	41%
Southeast Tributary at Peyton Highway	JHR0610	2.7	34	92	150	500	52	130	210	650	53%	41%	40%	30%
Southeast Tributary at Confluence with Main stem	JHR0650	4.3	38	110	180	670	54	150	230	790	42%	36%	28%	18%
At Confluence with Geick Basin	Haegler	16.6	190	570	950	3,200	550	1,300	2,000	5,600	189%	128%	111%	75%

Table 4-11 Volume Summary Comparison for the Haegler Ranch Drainage Basin

Key Location	HEC-HMS Element	Area (sq mi)	Existing Volume (ac-ft)				Future Volume (ac-ft)				Future Volume Increase (%)			
			2-yr	5-yr	10-yr	100-yr	2-yr	5-yr	10-yr	100-yr	2-yr	5-yr	10-yr	100-yr
Main stem at US 24	JHR0030	0.5	4.7	11	16	41	8.9	16	22	50	89%	45%	38%	22%
Main stem at Judge Orr Road	JHR0056	0.9	6.4	16	24	66	11	22	31	77	72%	38%	29%	17%
Main stem at Falcon Highway	JHR0145	3.3	17	46	72	210	54	100	140	310	218%	117%	94%	48%
Main stem at Jones Road	JHR0370	8.6	75	170	250	670	120	240	340	800	60%	41%	36%	19%
Main stem at Peyton Highway	JHR0465	10.7	95	220	320	840	140	290	400	970	47%	32%	25%	15%
Southeast Tributary at Jones Road	JHR0570	1.8	13	31	46	130	16	36	52	140	23%	16%	13%	8%
Southeast Tributary at Peyton Highway	JHR0610	2.7	18	45	68	190	21	50	73	200	17%	11%	7%	5%
Southeast Tributary at Confluence with Main stem	JHR0650	4.3	22	59	92	270	25	64	98	280	14%	8%	7%	4%
At Confluence with Geick Basin	Haegler	16.6	120	290	440	1,200	170	370	530	1,400	42%	28%	20%	17%



URS

9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

5,000 2,500 0 5,000 Feet

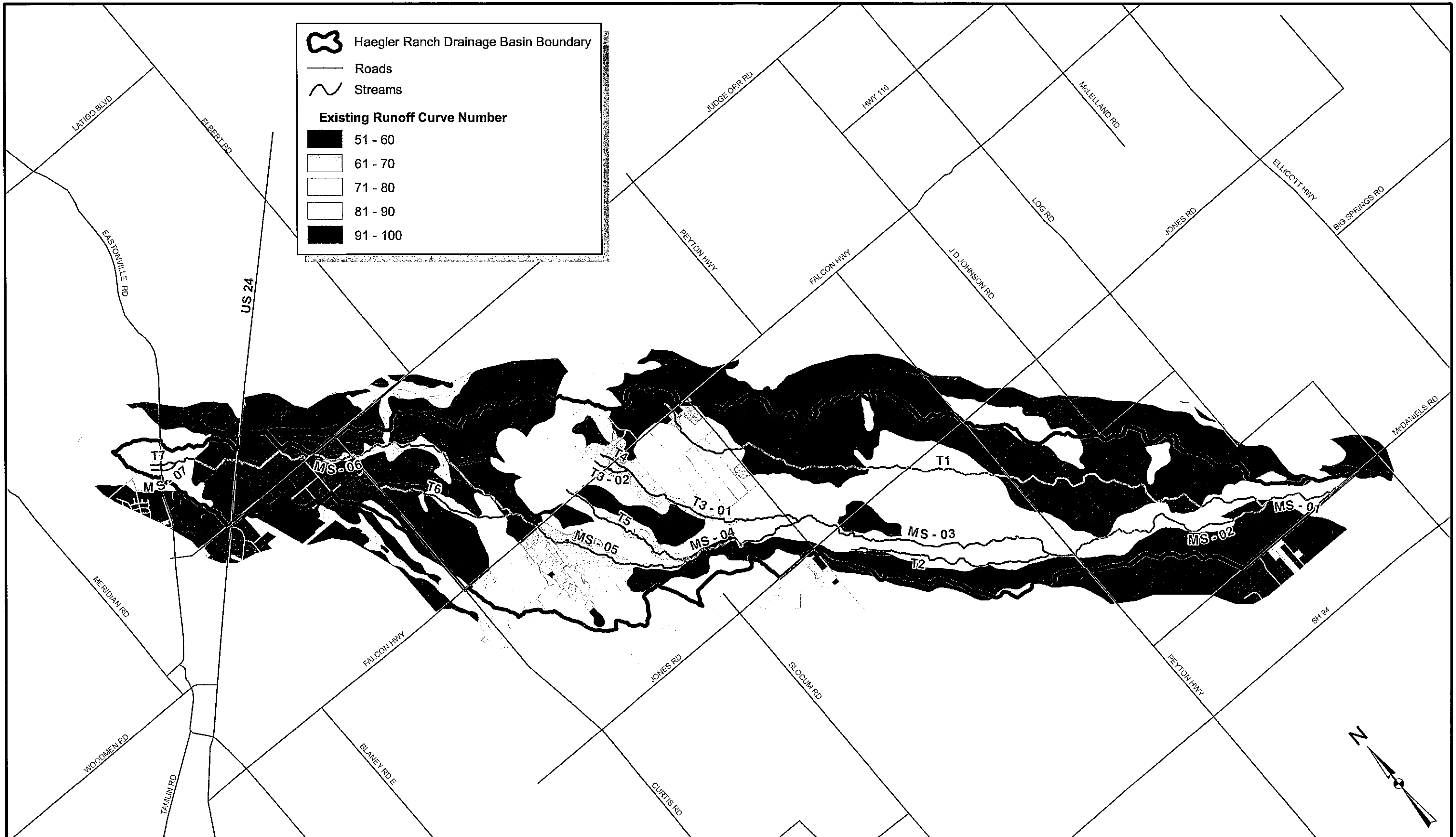
1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

SUBBASIN DELINEATION
FIGURE 4-1

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

5,000 2,500 0 5,000 Feet
1" = 5,000'

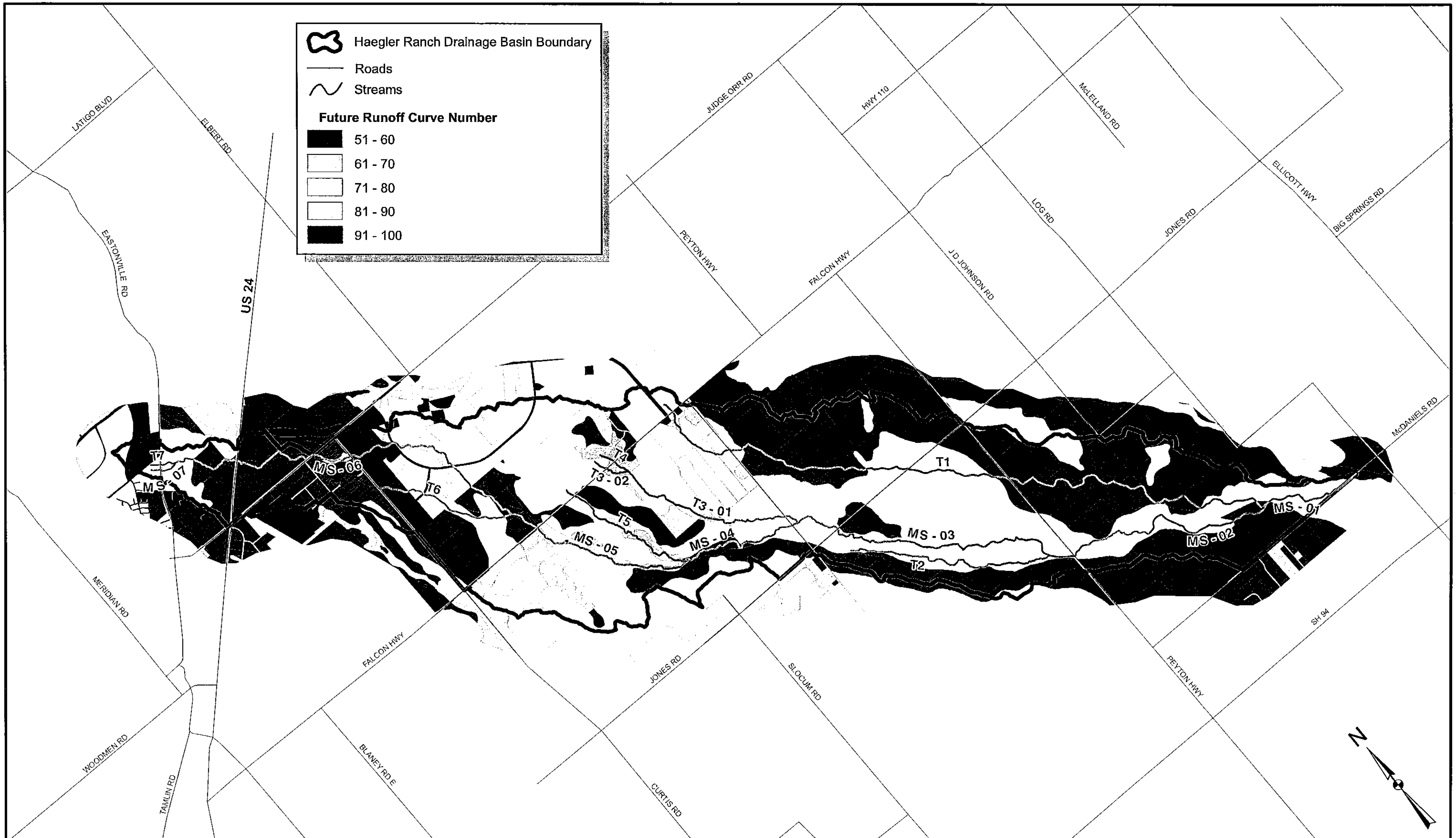
DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

EXISTING RUNOFF CURVE NUMBERS

FIGURE 4-2

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

FUTURE RUNOFF CURVE NUMBERS

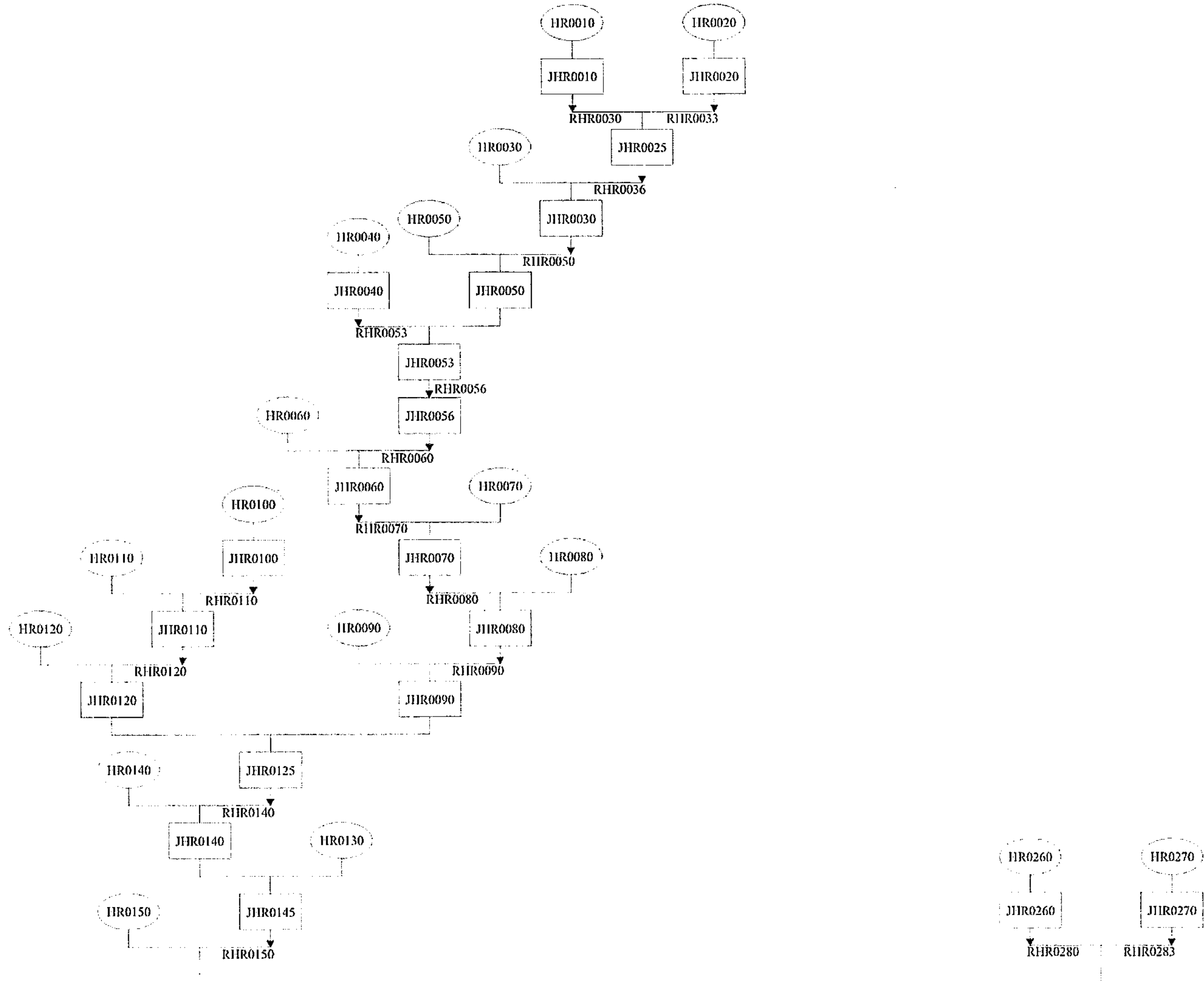
FIGURE 4-3

URS NO. 21711039

Figure 4-4 Existing and Future Conditions Hydrologic Model

SEE MAP POCKETS IN BACK OF REPORT

This page intentionally left blank.



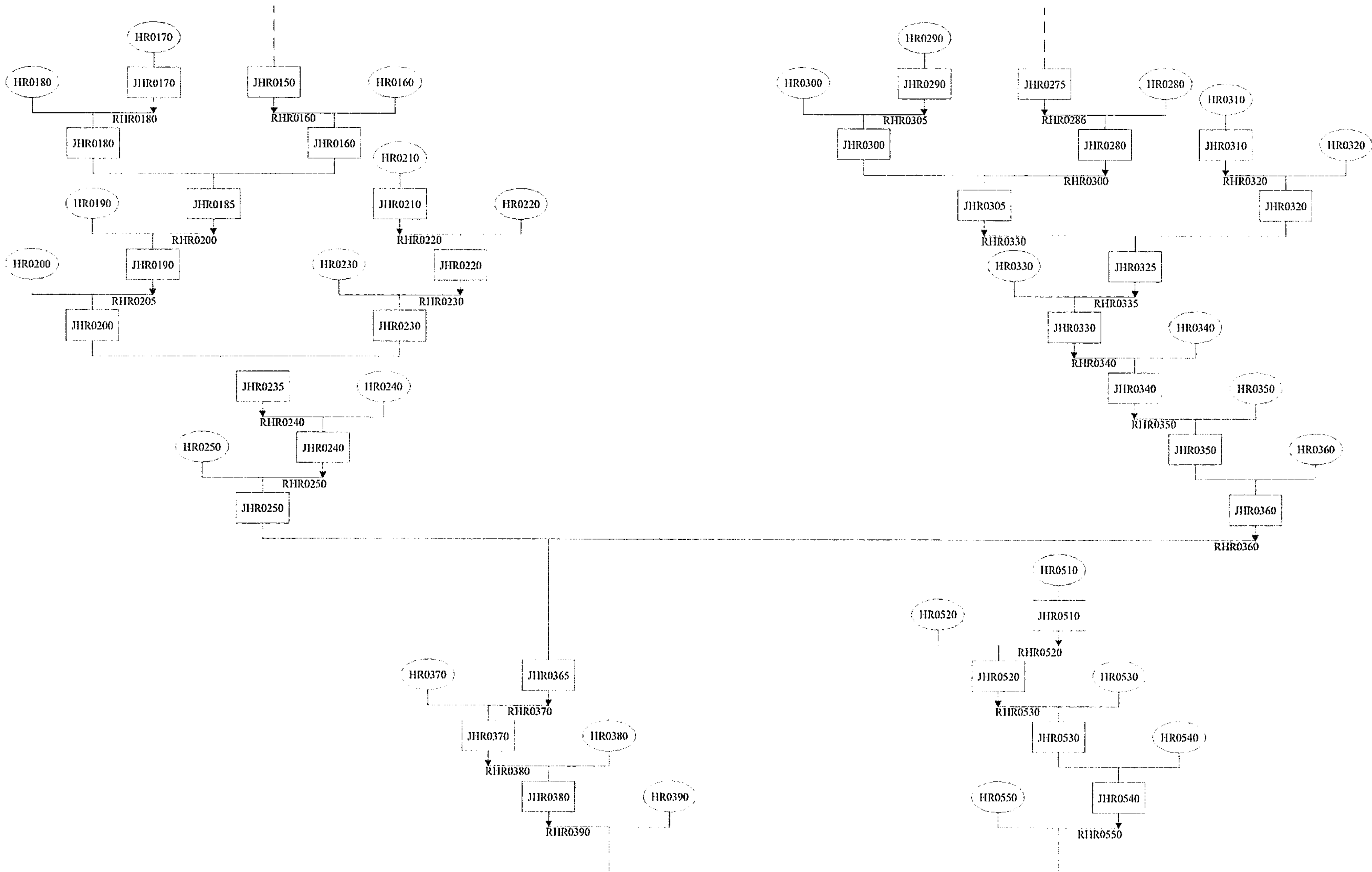
URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 05/08

HAEGLER RANCH DRAINAGE BASIN

HYDROLOGIC CONNECTIVITY
SHEET 1
FIGURE 4-5

URS NO. 21711039



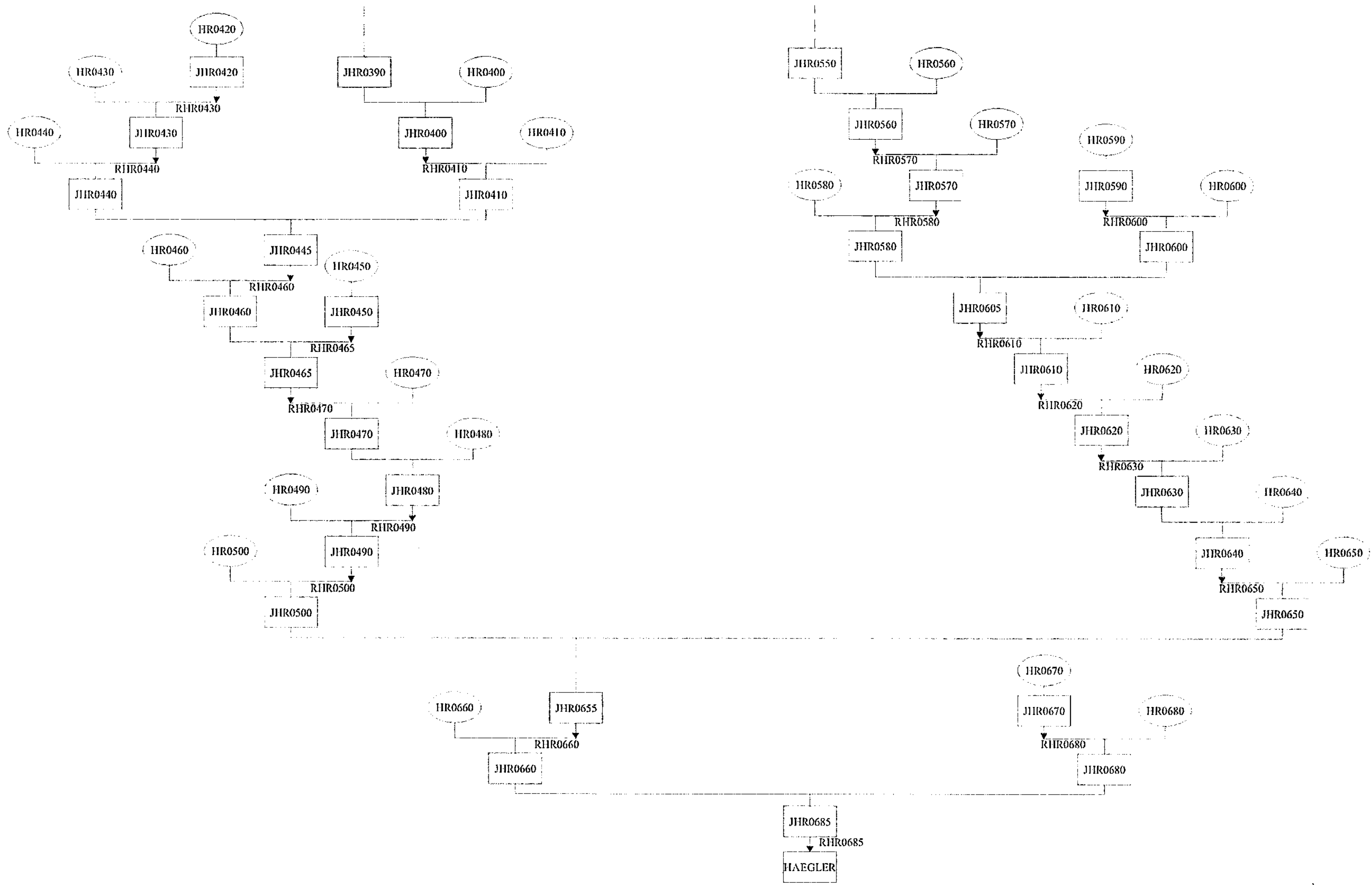
URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 05/08

HAEGLER RANCH DRAINAGE BASIN

HYDROLOGIC CONNECTIVITY
SHEET 2
FIGURE 4-5

URS NO. 21711039



URS

9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 05/08

HAEGLER RANCH DRAINAGE BASIN

HYDROLOGIC CONNECTIVITY

SHEET 3

FIGURE 4-5

URS NO. 21711039

5.0 HYDRAULIC ANALYSIS

5.1. Overview

Hydraulic analyses for existing conditions were computed for the 8 channel reaches within the Haegler Ranch Drainage Basin to model the flood events for the 2-, 5-, 10-, and 100-year recurrence interval flows. Hydraulic reaches studied are shown in Figure 5-1. Hydraulic analyses were conducted using the USACE Hydrologic Engineering Center-River Analysis System Version 3.1.3 (HEC-RAS). The employed methodology, models characteristics, and input data used in the hydraulics models are described in this section.

The hydraulic analysis of Haegler Ranch main stem was performed by dividing the basin into several reaches, which cover approximately 31 miles from the headwaters near Eastonville Road to its confluence with the unnamed tributary of Geick Ranch Drainage Basin. The Haegler Ranch main stem is primarily a grass-lined swale, with defined channels near road crossings that dissipate as the flow moves downstream.

5.2. Flood History

During the 1999 calendar year, a precipitation record was set for the Colorado Springs area. Haegler Ranch Drainage Basin also experienced this record precipitation. The 1999 flood event in Haegler Ranch Drainage Basin was caused by long periods of rainfall coupled with brief but intense storms. Several significant rainfall events occurred between March and August 1999 (FEMA 1999). The most pronounced event occurred April 28 to May 1 with a total of 5.59 in. (National Weather Service gauge, Colorado Springs Airport), only three days after a slightly smaller storm with a total of 1.79 in. At Meridian Road, Falcon Highway and East Blaney Road, culverts washed out and roadway embankments were damaged.

The spring of 1995 was extremely wet, with 7.8 in. of rain in June. Major flooding also occurred in spring 1965 when events very similar to the 1999 flood event took place. In 1965, 5.47 in. of rain was recorded at the Colorado Springs Airport in four days immediately after a series of ongoing, smaller events. Residents said that the 1965 storm centered more north and east of Falcon than the 1999 storm, and Ellicott Highway was completely washed out (FEMA 1999). These flood events clearly show the potential for severe flooding in the Haegler Ranch Drainage Basin.

5.3. Hydraulic Structure Inventory

As part of the field investigation, existing drainage facilities were inventoried. The size, type, and condition were recorded for the bridges, culverts, channels, inlets, pipes, and miscellaneous drainage features in the basin. An inventory of the major structures is presented in Figure 5-2 and Figure 5-3.

5.4. HEC-RAS Modeling

Hydraulic modeling was completed using HEC-RAS to perform one-dimensional, steady flow hydraulic calculations for each reach and a geospatially referenced river model in USACE Hydrologic Engineering Center – Geospatial River Analysis System Version 4.1 (HEC-GeoRAS).

In ArcMap®, the stream centerlines, banks, flow paths, cross-sections, and Manning's roughness coefficients were defined for the basin. The stream centerline follows the channel thalweg to define the reach network. The banks differentiate the 2-yr low flow channel from the floodplain channel. The flowpaths identify the centroid of the flow in the left overbank, main channel, and right overbank in order to determine the respective reach lengths. The cross-sections use the topography to acquire information along the reach. The Manning's roughness coefficients are defined for the channel and floodplains for the cross-section data. Cross-section topography data was obtained by using the 2-ft contour referenced earlier in Section 2.3 (AME 2004). From the 2-ft contours, a triangulated irregular network (TIN) was created for the digital terrain model in HEC-GeoRAS. A HEC-GeoRAS import file that contained three-dimensional coordinates for the stream centerlines and cross-sections, as well as reach stations, bank stations, reach lengths, stream topology, and Manning's roughness coefficients was imported into HEC-RAS.

Bridges, culverts, levees, and ineffective flow were added to the HEC-RAS model after import from HEC-GeoRAS. For the culvert and bridge crossings, a field survey was conducted to get detailed cross-section data. Physical parameters for surveyed structures were incorporated into the hydraulic model using HEC-RAS bridge/culvert and cross-section data editors. Structures were modeled as if they were free of any major obstructions to reflect properly maintained conditions. However, many of the culverts have reduced capacities due to sedimentation, vegetation growth, and the accumulation of debris. Cleaning and maintenance of these culverts is required to restore their flood flow capacities. Levees were defined in the cross-sections to represent disconnected low lying areas using the HEC-RAS cross-section data editor. Ineffective flow areas were defined to represent areas that contain water in a flood event but do not effectively convey flow.

5.5. Reach Delineation

Reaches were delineated for channels of Haegler Ranch Drainage Basin for areas that drain at least 100 ac and channels that include stormwater improvement projects. The reaches were evaluated based upon the existing topography, physical condition of the channel, and the floodplains along the major drainageways. The delineated reaches shown in Figure 5-1 are described as follows:

- Main Stem (MS-01) – This channel extends from the confluence of the main stem and Tributary 1 in subbasin HR0660 to the outlet of the Haegler Ranch in subbasin HR0680 on the north side of McDaniels Road. The channel is a grass swale that flows into a grass-lined ditch on the north side of McDaniels Road.
- Main Stem (MS-02) – This channel extends from the confluence of the main stem with Tributary 2, just northwest of Peyton Highway in subbasin HR0460, to the confluence of the main stem and Tributary 1 in subbasin HR0660. The channel is a grass swale with one culvert crossing at Peyton Highway.
- Main Stem (MS-03) – This channel extends from the confluence of the main stem with Tributary 3, just east of Murr Road in subbasin HR0370, to the confluence of the main stem with Tributary 2, just northwest of Peyton Highway in subbasin HR0460. The channel is parallel to T2, and varies between a grass swale and an alluvial sand bed with one culvert crossing at Jones Road.
- Main Stem (MS-04) – This channel extends from the confluence of the main stem with Tributary 5 in subbasin HR0240 to the confluence of the main stem with Tributary 3, just east of Murr Road in subbasin HR0250. The channel is a grass swale with one culvert crossing at Murr Road.

- Main Stem (MS-05) – This channel extends from the confluence of the main stem with Tributary 6 north of Falcon Highway in subbasin HR0140 to the confluence of the main stem with Tributary 5 in subbasin HR0200. The channel is a grass swale with one culvert crossing at Falcon Highway.
- Main Stem (MS-06) – This channel extends from the confluence of the main stem with Tributary 7, southeast of Eastonville Road in subbasin HR0030, to the confluence of the main stem with Tributary 6, just north of Falcon Highway in subbasin HR0090. The channel is a grass swale with two culvert crossings, one bridge crossing, and one overtopped roadway at Judge Orr Road.
- Main Stem (MS-07) – This channel extends from subbasin HR0010 northwest of Eastonville Road to the confluence of the main stem with Tributary 7, southeast of Eastonville Road in subbasin HR0030. The channel is a grass swale with one culvert crossing at Eastonville Road.
- Tributary 1 (T1) – This channel extends from subbasin HR0510 just north of Falcon Highway to the confluence of the main stem at subbasin HR0650. The channel is long, dominated by a grass swale with low points along the channel, and has 4 culvert crossings.
- Tributary 2 (T2) – This channel extends from subbasin HR0420 just south of Jones Road to the confluence of the main stem at subbasin HR0440 to the northwest of Peyton Highway. The channel is parallel to MS-03, and varies between a grass swale and an alluvial sand bed channel with diversion structures such as pond embankments and berms.
- Tributary 3 (T3-01) – This channel extends from subbasin HR0330 at the confluence with Tributary 4, just south of Falcon Highway, to the confluence with the main stem east of Murr Road, at subbasin HR0360. The channel is a grass swale with two culvert crossings in a large lot residential development.
- Tributary 3 (T3-02) – This channel extends from subbasin HR0290 just north of Falcon Highway to the confluence with Tributary 4, just south of Falcon Highway, in subbasin HR0300. The channel is a grass swale with one culvert crossing at Falcon Highway.
- Tributary 4 (T4) – This channel extends from subbasin HR0280 north of Falcon Highway to the confluence with Tributary 3, just south of Falcon Highway, in subbasin HR0300. The channel is a grass swale with one culvert crossing at Falcon Highway.
- Tributary 5 (T5) – This channel extends from subbasin HR0210 just north of Falcon Highway to to the confluence with the main stem in subbasin HR0230. The channel is a grass swale with one culvert crossing at Falcon Highway.
- Tributary 6 (T6) – This channel extends from subbasin HR0100 west of Curtis Road to the confluence of the main stem north of Falcon Highway in subbasin HR0120. The channel is a grass swale with one culvert crossing at Curtis Road.
- Tributary 7 (T7) – This channel extends from subbasin HR0020 northwest of Eastonville Road to the confluence of the main stem, southeast of Eastonville Road, in subbasin HR0030. The channel is a grass swale with one culvert crossing at Eastonville Road.

5.6. Manning's Roughness Coefficients

Manning's roughness coefficients for each cross-section were estimated based on site visits and aerial photographs. Multiple Manning's roughness coefficients were used across the cross-section as necessary to accurately describe changes in vegetative cover between the main channel and overbank areas. The values for the Manning's roughness coefficients in the channel and the floodplains are taken from the Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains by the USGS (WSP 2339). This manual was used since the Manning's roughness coefficients can be adjusted for surface irregularities, variation in cross-sections, obstructions, vegetation, and meandering. The Manning's roughness coefficients for the channels and floodplains associated with different types of land cover are summarized in Table 5-1.

Table 5-1 Manning's Roughness Coefficients for the Haegler Ranch Drainage Basin

Land Surface Type	Manning's Roughness Coefficients
Channel	
Grass swale	0.055
Grass-lined ditch	0.032
Sand bed	0.025
Floodplain	
Grass	0.065
Trees	0.150
Light Brush	0.074
Brush	0.100
Earth	0.038
Asphalt / Concrete	0.020

Notes:
[1]Source: Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains by the USGS (WSP 2339).

5.7. Cross-sections

Hydraulic cross-sections were initially placed approximately 500-ft apart along reaches, and additional cross-sections were added to represent confluences, road crossings and changes in channel form. Cross-sections were automatically stationed from downstream to upstream along the reach. Each cross-section was adjusted to extend across the entire floodplain and was placed perpendicular to the anticipated direction of flow in both the main channel and left/right overbanks. The cross-sections were bent in some locations to meet this requirement, as described in Chapter 3 of HEC-RAS Hydraulic Reference Manual (Version 3.1, November 2002).

Additional cross-sections were added at structures such as bridges and culverts. At each structure, four cross-sections were added to the HEC-RAS model. These four cross-sections included an upstream cross-section prior to flow contraction, a cross-section at the upstream face of the structure, a cross-section at the downstream face of the structure, and a downstream cross-section where flow is fully expanded. All bridge and culvert crossings were field surveyed to determine their size, inverts, and material.

Expansion and contraction coefficients were estimated based on the ratio of expansion and contraction of the effective flow area in the floodplain occurring at cross-sections and at roadway crossings. For subcritical flow conditions and where the change in the stream cross-section was gradual, contraction and expansion coefficients of 0.1 and 0.3, respectively, were used. Wherever the change in effective cross section area was abrupt, such as at bridges and culverts, contraction and expansion coefficients of 0.3 and 0.5, respectively, were used.

5.8. Levees and Ineffective Flow

Levees were used to describe portions of a cross-section in which water does not actively flow. Levees represent physical barriers, that may be either man-made or naturally occurring, that prevent the flow from reaching a low-lying area outside the channel. Once the levee is overtopped, the flow outside the levee is ineffective flow.

Ineffective flow areas are used to describe portions of a cross section in which water in not actively flowing. This ineffective flow can be in a side channel or on the upstream or downstream cross sections of a structure. All ineffective flow is considered as permanent, and will not flow once the levee or structure is overtopped.

5.9. Bridges and Culverts

The field survey data and the TIN were combined to create upstream and downstream cross-sections for bridges and culverts along the reaches. The highest energy answer was selected for low flow methods. For bridges, the deck/roadway, pier, and sloping abutments were input where appropriate. For culverts, the shape and dimensions were input.

Entrance loss coefficients estimate the amount of energy lost as the flow enters into culverts and is used to determine the upstream headwater elevation for outlet control computations. Entrance loss coefficients for different types of culverts were selected from Tables 6.3, 6.4, and 6.5 of HEC-RAS Hydraulic Reference Manual (Version 3.1, November 2002). Exit losses are set to 1.0 for a typical culvert with sudden expansion as per the Reference Manual.

5.10. Steady Flow and Boundary Conditions

Steady flow data were entered for all reaches based on the results of the hydrologic model as outlined in Section 4.0. Steady flow data corresponding to recurrence intervals of 2-, 5-, 10-, and 100-years for existing conditions for each reach were determined at different locations used in the HEC-RAS model.

Water surface elevation boundary conditions were determined using the normal depth method at the upstream end and downstream end of all reaches. This boundary condition requires input of the energy grade line slope, which is assumed to be bed slope, at the downstream and upstream boundaries for the mixed-flow regime and can be approximated from contour data. The upstream and downstream boundary conditions were entered into the HEC-RAS model.

5.11. Flow Regime

The HEC-RAS model was run in a mixed flow regime to observe areas of subcritical flow, supercritical flow, hydraulic jumps, and draw downs. The model was then run using only subcritical flow, which was then used to delineate the 100-year floodplain.

5.12. Approximate Floodplains

Approximate floodplains for the 100-year existing condition flow have been delineated for Haegler Ranch Drainage Basin using HEC-RAS and HEC-GeoRAS. Floodplain limits and profiles for the 100-year storm event can are shown in Figure 5-4. The approximate floodplain limits and profiles were used to assess where hydraulic inadequacies exist along the major drainageways.

The approximate floodplain information shown on the plans can be used for identification of flood prone areas along the major drainageways and to aid in the evaluation of alternative plans. The approximate floodplain data contained herein is not intended to replace the information presented in the City of Colorado Springs and El Paso County Flood Insurance studies (FEMA 1999), but should be used as a planning tool for drainageway development projects.

The structures identified as being in the approximate floodplain shown in Figure 5-4 are listed in Table 5-2. This table has been prepared using available survey and aerial photo graphic data, but it has not been field verified.

5.13. Existing Deficiencies and Upgrades

Hydraulic capacities were estimated for the 19 culverts, 1 bridge crossing, and 2 road crossings with no culvert or bridge along the 8 channels in the hydraulic models, to determine the existing deficiencies. The hydraulic capacity of a road crossing was assumed to be exceeded when the hydraulic grade line reached the road surface for the 100-year HEC-RAS model. A summary of the road crossings evaluated can be found in Table 5-3.

Of the 22 road crossings, 20 roads are overtopped and 2 crossings have existing 100-year flow capacities. For the 20 crossing that are currently insufficient, the facilities necessary to provide 100-year conveyance were determined, as listed in Table 5-3. These necessary facilities are based on approximate culvert capacity calculations in Appendix B.

Table 5-2 Structures in the Approximate Floodplain

Structure No.	Description	Location	Reach	Nearest Cross-Section	Approximate Flooding Depth, ft
1	home	HR0680	MS-01	1931	<1
2	lg. shed	HR0680	MS-01	1931	<1
3	garage	HR0680	MS-01	1931	<1
4	med. barn	HR0680	MS-01	1931	<1
5	shade str.	HR0680	MS-01	1931	<1
6	home	HR0680	MS-01	2426	<1
7	sm. shed	HR0680	MS-01	2426	<1
8	sm. barn	HR0680	MS-01	2426	<1
9	home	HR0680	MS-01	2426	<1
10	lg. barn	HR0660	MS-01	6205	<1
11	shop	HR0460	MS-02	19652	<1
12	sm. shed	HR0460	MS-02	19233	1.5
13	sm. shed	HR0460	MS-02	19233	1.7
14	sm. barn	HR0250	MS-04	36185	<1
15	mobile home	HR0250	T3-01	1009	<1
16	barn/stalls	HR0570	T1	24761	<1
17	shade str.	HR0570	T1	24761	<1
18	home	HR0520	T1	32854	<1
19	med. barn	HR0520	T1	33123	<1
20	home	HR0520	T1	33834	<1
21	sm. shed	HR0520	T1	33834	3.9
22	sm. shed	HR0520	T1	33985	2.7
23	lg. shed	HR0520	T1	34275	<1
24	home	HR0520	T1	34539	1.5
25	lg. shed	HR0520	T1	34539	<1
26	lg. shed	HR0520	T1	34539	<1
27	shop	HR0570	T1	35004	<1
28	home	HR0520	T1	35004	<1
29	home	HR0520	T1	35004	<1
30	home	HR0520	T1	35209	2.7
31	garage	HR0520	T1	35209	1.7
32	sm. shed	HR0520	T1	35540	1.7
33	home	HR0520	T1	35209	<1
34	garage	HR0520	T1	35540	<1
35	home	HR0520	T1	35540	<1
36	home	HR0520	T1	35540	<1
37	garage	HR0570	T1	35927	<1
38	sm. shed	HR0520	T1	35540	<1
39	home	HR0520	T1	35927	1.7
40	garage	HR0520	T1	35927	2.7
41	garage	HR0520	T1	36037	<1
42	home	HR0520	T1	36037	<1

Table 5-2 Structures in the Approximate Floodplain

Structure No.	Description	Location	Reach	Nearest Cross-Section	Approximate Flooding Depth, ft
43	home	HR0520	T1	36351	2.9
44	garage	HR0520	T1	36721	<1
45	home	HR0520	T1	36721	2.8
46	sm. barn	HR0520	T1	36721	<1
47	home	HR0570	T1	36721	<1
48	garage	HR0520	T1	36971	<1
49	home	HR0140	MS-05	52834	<1
50	shop	HR0140	MS-05	52834	<1
51	med. barn	HR0140	MS-05	53369	<1
52	med. shed	HR0140	MS-05	53369	<1
53	med. barn	HR0140	MS-05	53369	<1
54	lg. shed	HR0140	MS-05	53369	<1
55	sm. shed	HR0140	MS-05	53369	<1
56	sm. shed	HR0130	MS-06	55426	<1
57	home	HR0130	MS-06	54855	<1
58	shop	HR0130	MS-06	55883	<1
59	home	HR0100	T6	7733	<1
60	lg. shed	HR0100	T6	7994	<1
61	OMIT- NOT FLOODED				
62	med. barn	HR0060	MS-06	66759	<1
63	med. shed	HR0060	MS-06	66759	<1
64	mobile home	HR0220	T5	8074	<1
65	med. shed	HR0220	T5	8074	<1
66	med. shed	HR0220	T5	8074	<1
67	med. shed	HR0520	T1	36200	<1
Propane Tanks					
111	p.tank w.house1	HR0680	MS-01	1931	<1
112	p.tank w.house6	HR0680	MS-01	2426	1.1
113	p.tank w.house9	HR0680	MS-01	2426	<1
114	p.tank w.house19	HR0520	T1	33123	<1
115	p.tank w.house20	HR0520	T1	33985	2.1
116	p.tank w.house30	HR0520	T1	35209	1.7
117	p.tank w.house35	HR0520	T1	35540	<1
118	p.tank w.house36	HR0520	T1	35540	<1
119	p.tank w.house39	HR0520	T1	35927	1.7
120	p.tank w.house43	HR0520	T1	36721	2.9
121	p.tank w.house47	HR0520	T1	36721	<1
122	p.tank w.house49	HR0140	MS-05	52834	<1
123	p.tank w.house57	HR0130	MS-06	54855	<1
124	p.tank w.house59	HR0100	T6	7733	1.5
125	p.tank w.house64	HR0220	T5	8074	<1

Table 5-3 Existing Hydraulic Deficiencies

Facility Number	Road Crossing	Channel	Existing Size	Existing 100-yr Flow (cfs)	Deficiency
301	Peyton Highway	Main Stem (MS-02)	2-33"X48" CMPs	2,500	Overtops
N/A	Peyton Highway	Tributary 1 (T1)	No Culvert	500	Overtops
401	Jones Road	Tributary 1 (T1)	2-24" CMPs	370	Overtops
402	Jones Road	N/A	15" RCP	N/A	N/A
403	Jones Road	Main Stem (MS-03)	3-60" CMPs	2,300	Overtops
404	Jones Road	N/A	18" CMP	N/A	N/A
405	Murr Road	Main Stem (MS-04)	66" RCP	1,700	Overtops
406	Jones Road	N/A	4.1' x 6.9' RCP	N/A	N/A
407	Murr Road	Tributary 3 (T3-01)	66" RCP	670	Overtops
501	Murr Road	N/A	2-14" RCP	N/A	N/A
502	Murr Road	N/A	2-18" CMP	N/A	N/A
503	Flat Creek Road	N/A	30" CMP	N/A	N/A
504	Flat Creek Road	N/A	18" CMP	N/A	N/A
505	Flat Creek Road	N/A	36" CMP	N/A	N/A
506	Flat Creek Road	N/A	60" CMP	N/A	N/A
507	Peerless Farms Road	Tributary 3 (T3-01)	60" CMP	600	Overtops
508	Whipsaw Road	N/A	30" CMP	N/A	N/A
509	Murr Road	Tributary 1 (T1)	2-15" RCPs	220	Overtops
510	Prospero Road	N/A	18" CMP	N/A	N/A
511	Southfork Dr	N/A	24" CMP	N/A	N/A
512	Falcon Grassy Hts	N/A	2-12" CMP	N/A	N/A
513	Southfork Dr	N/A	36" CMP	N/A	N/A
514	Oil Baron Dr	N/A	30" CMP	N/A	N/A
601	Whiting Way	Tributary 1 (T1)	24" CMP	220	Overtops
602	Whipsaw Road	N/A	24" CMP	N/A	N/A
603	Murr Road	N/A	24" CMP	N/A	N/A
604	Max Road	Tributary 1 (T1)	18" CMP	220	Overtops
605	Max Road	N/A	2-24" CMP	N/A	N/A

Table 5-3 Existing Hydraulic Deficiencies

Facility Number	Road Crossing	Channel	Existing Size	Existing 100-yr Flow (cfs)	Deficiency
606	Prospero Road	N/A	2-24" CMP	N/A	N/A
N/A	Falcon Highway	Tributary 1 (T1)	No Culvert	33	Overtops
607	Falcon Highway	N/A	18" CMP	N/A	N/A
608	Falcon Highway	N/A	24" CMP	N/A	N/A
609	Falcon Highway	Tributary 3 (T3-02)	18" CMP	180	Overtops
610	Falcon Highway	Tributary 4 (T4)	24" CMP	200	Overtops
611	Falcon Highway	N/A	18" CMP	N/A	N/A
612	Falcon Highway	Tributary 5 (T5)	24" CMP	150	Overtops
613	Bobby Court	N/A	2-36" CMP	N/A	N/A
614	Southfork Dr	N/A	36" CMP	N/A	N/A
615	Southfork Dr	N/A	2-36" CMP	N/A	N/A
616	Southfork Dr	N/A	30" CMP	N/A	N/A
617	Clifford Dr	N/A	24" CMP	N/A	N/A
618	Southfork Dr	N/A	30" CMP	N/A	N/A
619	Southfork Dr	N/A	18" RCP	N/A	N/A
620	Oil Baron Dr	N/A	30" CMP	N/A	N/A
621	Sue Ellen Dr	N/A	36" CMP	N/A	N/A
622	Sue Ellen Dr	N/A	48" CMP	N/A	N/A
623	Sue Ellen Dr	N/A	24" CMP	N/A	N/A
624	Sue Ellen Dr	N/A	18" CMP	N/A	N/A
625	Pamela Way	N/A	30" CMP	N/A	N/A
626	Southfork Dr	N/A	24" CMP	N/A	N/A
627	Crebs Dr	N/A	3-30" CMP	N/A	N/A
628	Falcon Highway	Main Stem (MS-05)	2-60" CMPs	1,000	Overtops
629	Falcon Grassy Hts	N/A	24" CMP	N/A	N/A
630	Sagecreek Road	N/A	2-24" CMP	N/A	N/A
631	Sage Lake Court	N/A	18" CMP	N/A	N/A
632	Sagecreek Road	N/A	2-18" CMP	N/A	N/A

Table 5-3 Existing Hydraulic Deficiencies

Facility Number	Road Crossing	Channel	Existing Size	Existing 100-yr Flow (cfs)	Deficiency
633	Sagecreek Road	N/A	24" CMP	N/A	N/A
634	Sagecreek Road	N/A	24" CMP	N/A	N/A
701	Curtis Road	N/A	18" CMP	N/A	N/A
702	Curtis Road	Tributary 6 (T6)	36" CMP	120	Overtops
703	Curtis Road	Main Stem (MS-06)	24" CMP	590	Overtops
704	Judge Orr Road	Main Stem (MS-06)	Blocked Culvert	540	Overtops
705	Judge Orr Road	N/A	18" CMP	N/A	N/A
706	US 24	N/A	20" Steel Pipe	N/A	N/A
707	US 24	N/A	24" CMP	N/A	N/A
801	Pedestrain Bridge	Main Stem (MS-06)	Bridge	350	Meets Capacity
802	US24	Main Stem (MS-06)	2-66" CMPs	350	Meets Capacity
803	Eastonville Road	Main Stem (MS-07)	27"X21" CMP	25	Overtops
804	Eastonville Road	Tributary 7 (T7)	18" CMP	99	Overtops

Note: 69 Structures were cataloged and located. N/A indicates that the structure was not analyzed because it was not on one of the main channels.

5.14. Results

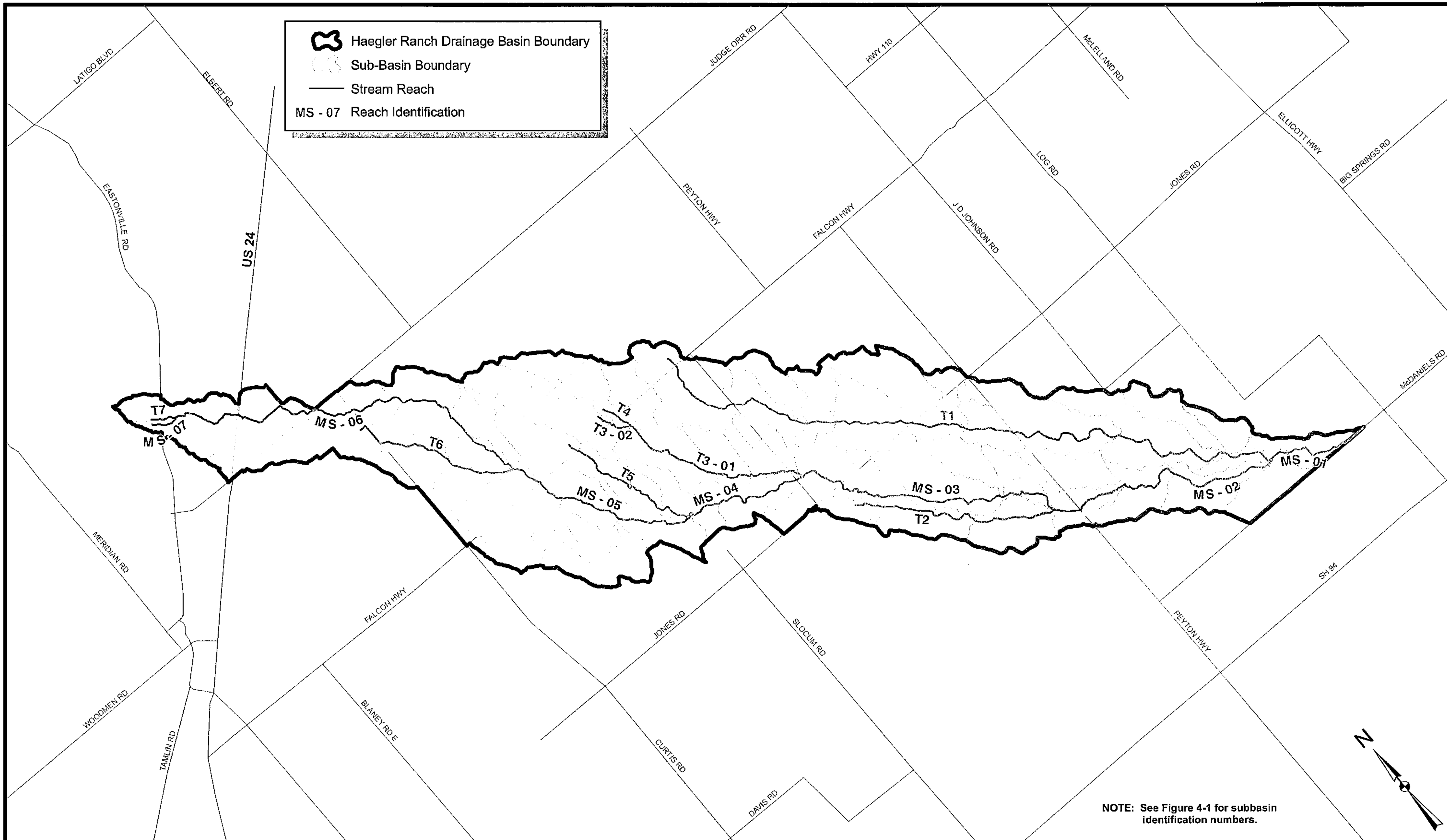
Hydraulic conditions from the hydraulic model results are summarized in Table 5-4. This includes channel velocity, flow depth, and top width for existing conditions at key locations. Water surface profiles for Haegler Ranch Drainage Basin for the 100-year recurrence interval flood for the existing conditions are presented in Figure 5-4 the HEC-RAS model for Haegler Ranch Drainage Basin for the existing conditions is provided in Appendix B.

The approximate 100-year floodplain as seen in Figure 5-4 varies from a contained floodplain with in a defined channel to a wide floodplain with shallow flooding. Three areas were designated as flooding: 1) the approximate 100-year floodplain as delineated by HEC-RAS, 2) split flow flooding that was estimated from HEC-RAS elevation upstream and contours, and 3) shallow areas connected to the floodplain with less than 1 foot of flooding.

Table 5-4 Existing Conditions HEC-RAS Model

Key Location	Reach and Station	HEC-RAS Result	Recurrence Intervals			
			2-yr	5-yr	10-yr	100-yr
Main stem at US 24	MS-06 72276	Channel velocity (ft/sec)	1.1	1.63	1.98	2.92
		Water surface depth in channel (ft)	1.36	2.44	3.24	6.49
		Top width (ft)	18.23	24.85	29.7	255.62
Main stem at Judge Orr Road	MS-06 67666	Channel velocity (ft/sec)	3.33	4.09	1.76	3.48
		Water surface depth in channel (ft)	0.52	1.04	1.05	1.35
		Top width (ft)	174.53	534.34	535.52	569.34
Main stem at Falcon Highway	MS-05 52353	Channel velocity (ft/sec)	1.05	1.6	2.04	3.59
		Water surface depth in channel (ft)	1.79	3.69	4.96	5.74
		Top width (ft)	31.42	83.76	556.41	592.33
Main stem at Jones Road	MS-03 33189	Channel velocity (ft/sec)	2.45	3.7	1.27	2.51
		Water surface depth in channel (ft)	3.2	5.83	9.25	10.46
		Top width (ft)	47.98	105.51	580.28	667.17
Main stem at Peyton Highway	MS-02 18474	Channel velocity (ft/sec)	0.16	0.4	0.59	1.43
		Water surface depth in channel (ft)	4.14	4.35	4.51	5.15
		Top width (ft)	813.21	871.68	882.22	925.27
Southeast Tributary at Jones Road	T1 22297	Channel velocity (ft/sec)	0.62	1.02	1.47	3.2
		Water surface depth in channel (ft)	2.45	3.52	3.59	3.82
		Top width (ft)	197.35	345.68	351.74	372.17
Southeast Tributary at Peyton Highway	T1 16611	Channel velocity (ft/sec)	1.67	2.25	2.65	4.05
		Water surface depth in channel (ft)	0.08	0.17	0.24	0.51
		Top width (ft)	239.82	241.36	242.51	247.41
Southeast Tributary at Confluence with Main stem	T1 410	Channel velocity (ft/sec)	3.44	0.11	0.18	0.67
		Water surface depth in channel (ft)	1.69	2.01	2.01	2.01
		Top width (ft)	31.89	1169.3	1169.3	1169.3
At Confluence with Geick Basin	MS-01 82	Channel velocity (ft/sec)	2.68	3.85	19.89	17.33
		Water surface depth in channel (ft)	1.45	2.17	1.11	2.36
		Top width (ft)	75.88	255.32	60.67	262.84

This page intentionally left blank.



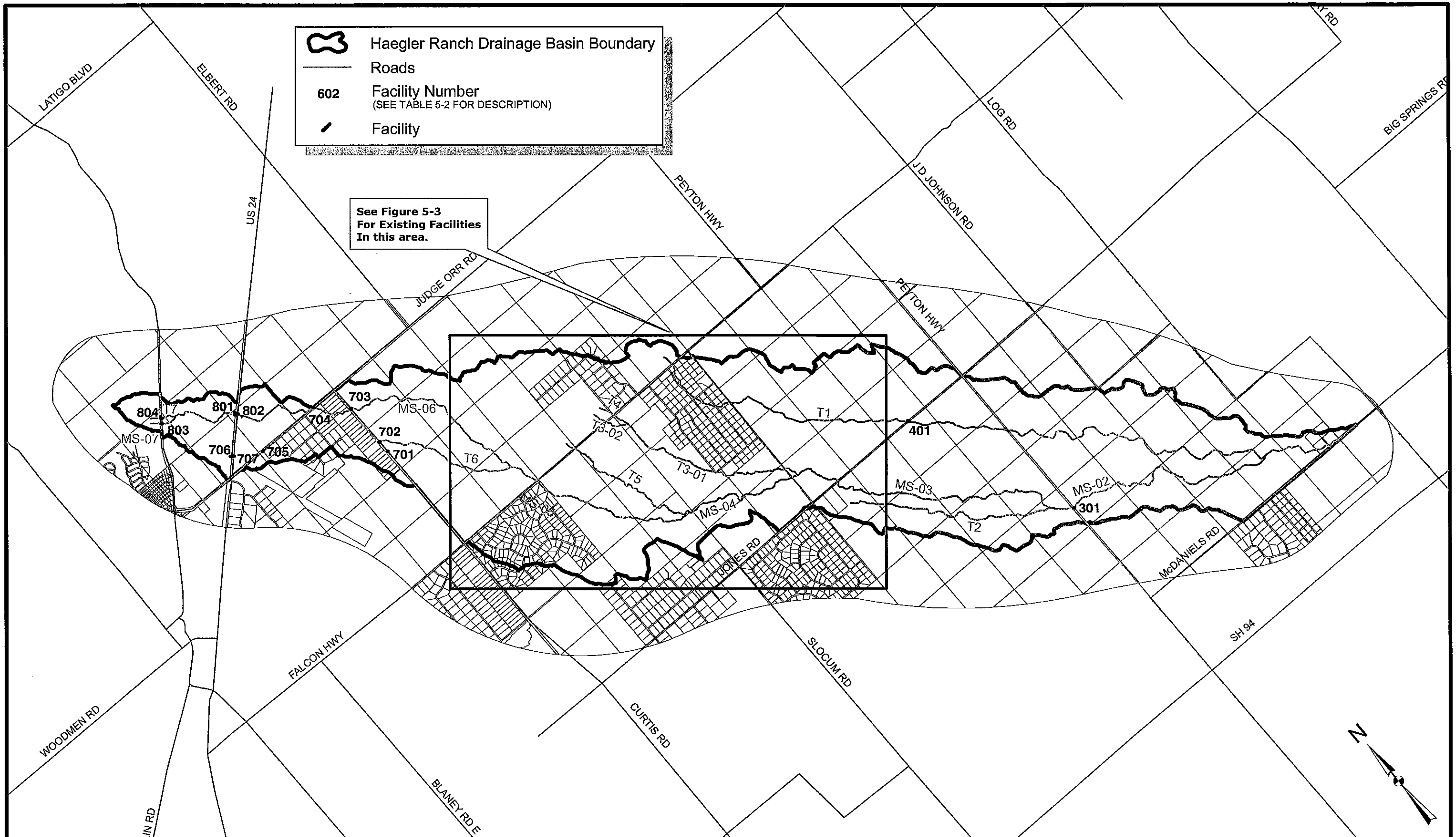
URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

HYDRAULIC REACHES
FIGURE 5-1

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

5,000 2,500 0 5,000 Feet

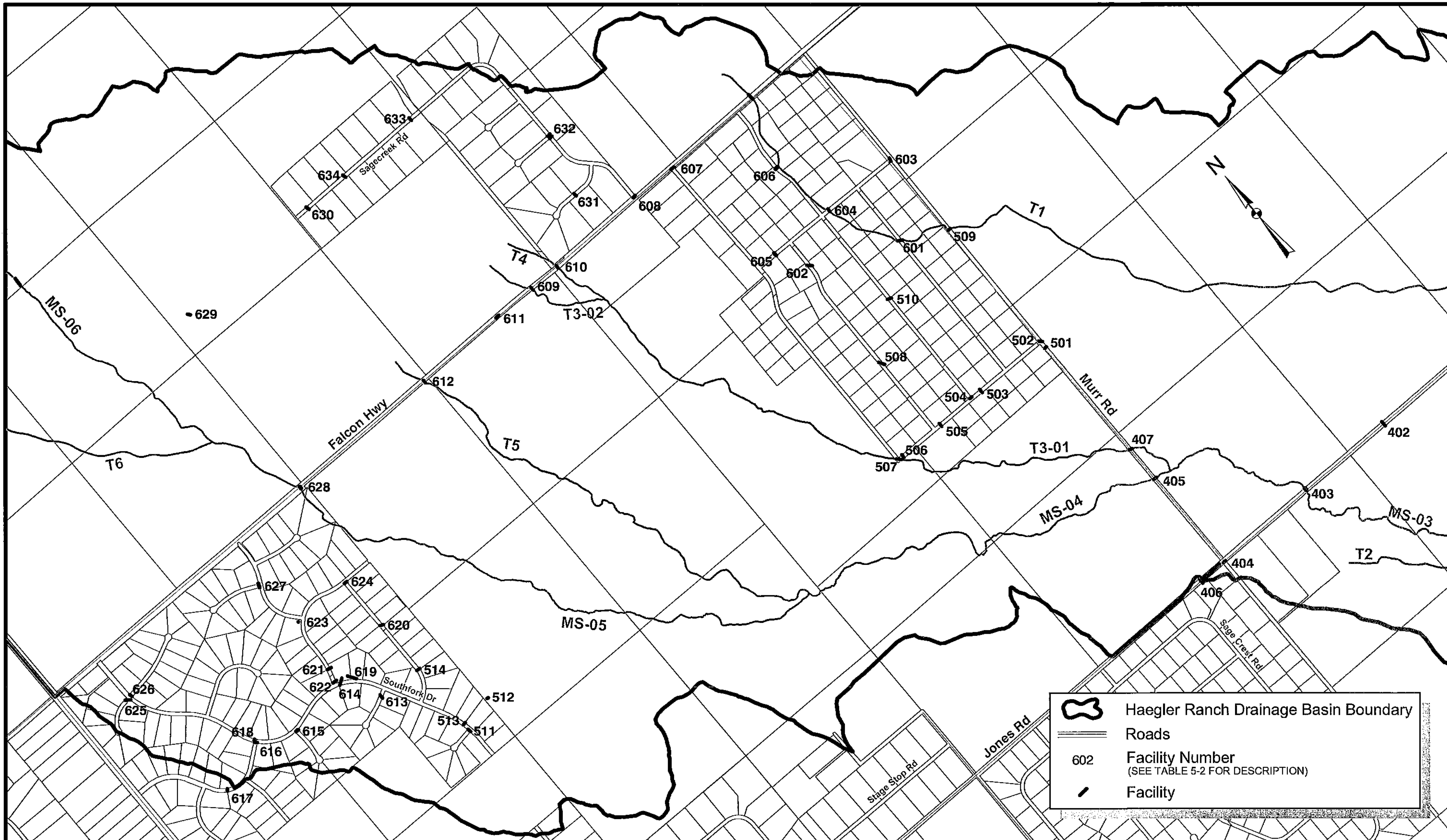
1" = 5,000'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

FACILITY INVENTORY A
FIGURE 5-2

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

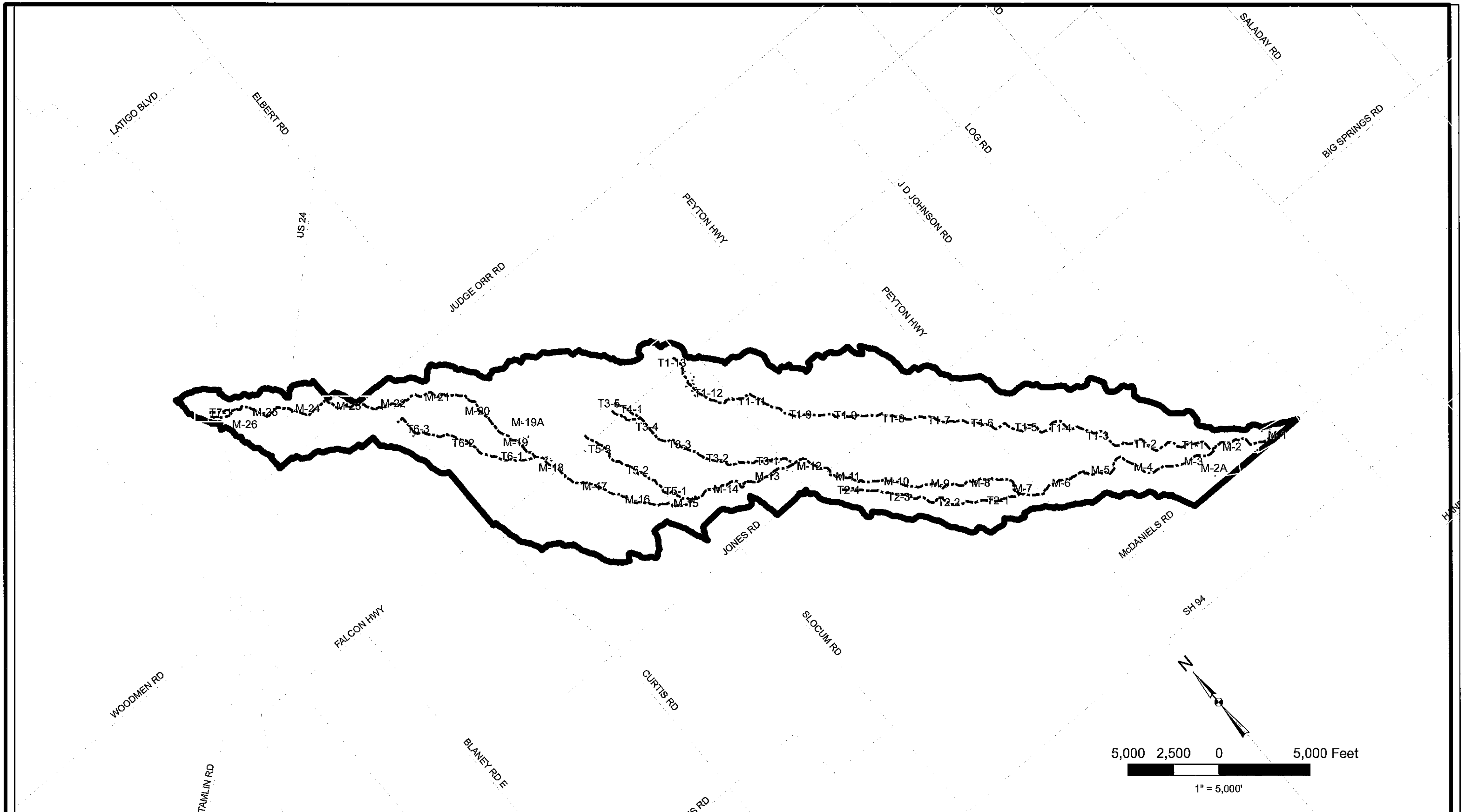
1,500 750 0 1,500 Feet
1" = 1,500'

DATE: 09/08

HAEGLER RANCH DRAINAGE BASIN

FACILITY INVENTORY B
FIGURE 5-3

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

DATE: 05/08

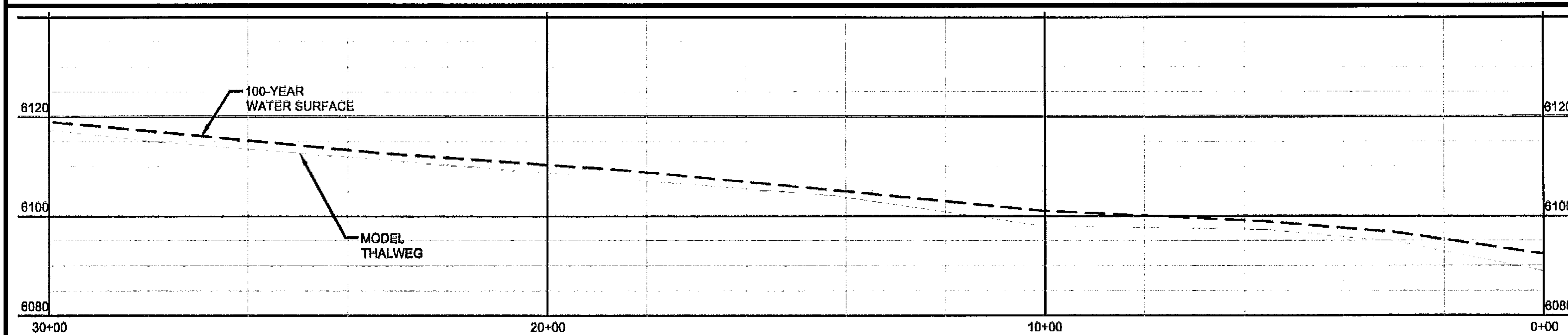
HAEGLER RANCH DRAINAGE BASIN

100-YEAR FLOOD LIMITS

SHEET INDEX

FIGURE 5-4

URS NO. 21711039



URS
9960 Federal Dr.
Suite 300
Colorado Springs, CO 80921
719.531.0001

Haegler Basin Boundary
Subbasin Boundaries
Approximate 100-Year Floodplain
Thalweg
Cross Sections
2' Contours

DATE: 10/08

HAEGLER RANCH DRAINAGE BASIN

APPROXIMATE 100-YEAR FLOOD LIMITS

SHEET M-1

FIGURE 5-4

URS NO. 21711039